RECORD OF DECISION

Operable Unit 3 – Marsh and River Sediment

Horseshoe Road and Atlantic Resources Corporation Sites,

Sayreville Township, Middlesex County, New Jersey

United States Environmental Protection Agency

Region II

June 2009

DECLARATION STATEMENT

RECORD OF DECISION

SITE NAME AND LOCATION

Horseshoe Road Site (EPA ID# NJD980663678)
Atlantic Resources Corporation Site (EPA ID# NJD981558430)
Sayreville Township, Middlesex County, New Jersey
Operable Unit 3 – Marsh and River Sediment

STATEMENT OF BASIS AND PURPOSE

This decision document presents the Selected Remedy for contaminated sediment located on the Horseshoe Road site and the neighboring Atlantic Resources Corporation site, in Sayreville, Middlesex County, New Jersey. The Selected Remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended, and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the Administrative Record file for these sites.

The State of New Jersey concurs with the Selected Remedy.

ASSESSMENT OF THE SITE

The response actions selected in this Record of Decision (ROD) are necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances from the sites into the environment.

DESCRIPTION OF THE SELECTED REMEDY

The response action described in this document represents the third and final phase of three planned remedial phases, or operable units, for the Horseshoe Road and Atlantic Resources Corporation (ARC) sites. It addresses sediment contamination at the sites. The first ROD, signed in September 2000, addressed buildings and above-ground structures at the two sites. The second ROD, signed in September 2004, addressed the contaminated on-site soil and groundwater at these sites.

The Selected Remedy described in this document involves the excavation and off-site disposal of marsh sediments, and dredging and disposal of river sediments. The major components of the selected response measure include:

- Excavation, transportation and disposal of approximately 21,000 cubic yards of contaminated sediments from the

Horseshoe Road/ARC Marsh;

- Dredging of approximately 14,000 cubic yards of contaminated sediments from the Raritan River;

- Off-site disposal of the dredged material;

- Backfilling and grading of all excavated or dredged areas with clean cover material;

- Institutional controls for the marsh sediments, such as a deed notice or covenant, to prevent exposure to residual sediment contamination that may exceed levels that would allow for unrestricted use;

- Institutional controls for the river sediments, to prevent disruption of cover in the event that materials are left at depth; and

- On-site restoration of approximately six acres of wetlands disturbed during implementation of the remedy.

DECLARATION OF STATUTORY DETERMINATIONS

Part 1: Statutory Requirements

The Selected Remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial actions to the extent practicable, and is cost-effective. EPA has determined that the Selected Remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the sites.

Part 2: Statutory Preference for Treatment

The Selected Remedy for sediment will not meet the statutory preference for the use of remedies that involve treatment as a principal element.

Part 3: Five-Year Review Requirements

This remedy will result in hazardous substances, pollutants, or contaminants remaining on the Horseshoe Road and Atlantic Resources Corporation sites above levels that allow for unlimited use and unrestricted exposure. Pursuant to Section 121(c) of CERCLA, a statutory review will be conducted within five years of the initiation of the remedial action to ensure that the remedy is, or will be, protective of human health and environment.

ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the Administrative Record file for the two sites.

- Chemicals of concern and their respective concentrations may be found in the "Site Characteristics" section.
- Baseline risk represented by the chemicals of concern may be found in the "Summary of Site Risks" section.
- A discussion of cleanup levels for chemicals of concern may be found in the "Remedial Action Objectives" section.
- A discussion of principal threat waste is contained in the "Principal Threat Waste" section of this document. None of the waste addressed in this operable unit is considered a principal threat.
- Current and reasonably-anticipated future land use assumptions are discussed in the "Current and Potential Future Site and Resource Uses" section.
- A discussion of potential land use that will be available at the sites as a result of the Selected Remedy is discussed in the "Remedial Action Objectives" section.
- Estimated capital, annual operation and maintenance (O&M), and total present worth costs are discussed in the "Description of Alternatives" section.
- Key factors that led to selecting the remedies (i.e., how the Selected Remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decisions) may be found in the "Comparative Analysis of Alternatives" and "Statutory Determinations" sections.

________________________________ __________

Walter E. Mugdan, Director
Emergency and Remedial
Response Division
EPA - Region II

Date

Decision Summary

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Horseshoe Road and Atlantic Resources Corporation Sites,

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SITE NAME, LOCATION AND BRIEF DESCRIPTION

The Horseshoe Road site is a 12-acre property located in Sayreville, Middlesex County, New Jersey. The site includes three areas: (1) the Sayreville Pesticide Dump (SPD); (2) the former Atlantic Development Corporation facility (ADC); and (3) the Horseshoe Road Drum Dump (HRDD). (See Appendix I, Figures 1 and 2.)

The adjacent Atlantic Resources Corporation (ARC) site is a 4.5-acre property also located on Horseshoe Road. It was the location of a precious metals recovery facility, operated by several companies, including the Atlantic Resources Corporation.

Both sites are located on the south shore of the Raritan River, and are bordered to the east by railroad tracks belonging to Conrail, on the opposite side of which lies property owned by the Middlesex County Utilities Authority (MCUA). Property to the west of the sites, on the Raritan River, is currently undeveloped, but portions are a wetland and the remainder was previously used to dispose of dredge spoils from local shipping channels. The Marsh that is a subject of this action is bounded on the east and south by the upland portions of the two sites and on the west by remnants of the Crossman Company. The Crossman Company mined clays for brick manufacturing, and built a rail line from its clay pits in Sayreville to the Raritan River. Remnants of the rail line and the former Crossman Dock bound the western edge of the Marsh. To the southwest lies the Sayreville facility of Gerdau Ameristeel, and to the southeast, approximately one-half mile away, lies a residential neighborhood containing approximately 47 homes. The areas described above are served by municipal water; about 14,000 people obtain drinking water from public wells within four miles of the sites.

SITE HISTORY AND ENFORCEMENT ACTIVITIES

Problems on Horseshoe Road first came to EPA's attention in 1981, when a brush fire at the HRDD area exposed approximately 70 partially filled drums containing acetonitrile, silver cyanide and ethyl acetate. The HRDD area was used for disposal from approximately 1972 into the early 1980s. The SPD area was also used for disposal, from about 1957 into the early 1980s. These two dump areas do not contain any buildings or structures.

The ADC facility contained three buildings that were owned or leased by many companies from the early 1950s to the early 1980s. The various operations included, at different times, the production of roofing materials, sealants, polymers, urethane and epoxy resins, resin pigments, wetting agents, pesticide intermediates and recycled chlorinated solvents.

The ARC site contained several interconnected buildings and structures, including a series of incinerators used for precious metals recovery. The facility recovered gold and silver from fly ash, x-ray and photographic film, circuit boards, building material and other materials. The operation also accepted spent solvents, which were used to fuel the incinerators. As with ADC, all the commercial operations at the ARC facility ceased in the early 1980s.

Since 1985, when the New Jersey Department of Environmental Protection (NJDEP) requested that EPA take the lead role in the cleanup of the sites, EPA has performed 10 removal actions. These removals stabilized the sites by removing more than 3,000 drums, cleaning up dioxin and mercury spills, emptying and disposing of materials found in numerous tanks and vats on both sites, and excavating and disposing of contaminated soils and debris.

Various companies operated at the ADC and ARC facilities from the late 1930s until the mid 1980s. The available information indicates that the various operators at ADC used the SPD area as a dump site, and the operators at the ARC site used the HRDD area for dumping. In 1995, EPA notified a number of former operators that they were considered potentially responsible parties (PRPs) for the cleanup of the Horseshoe Road site. Based upon the information available, EPA subsequently concluded that neither the property owner nor any of the former operators were viable companies with the resources to perform the necessary work at the Horseshoe Road site. Therefore, EPA has been performing site work, including the remedial actions, for the SPD and ADC areas with state and federal funds.

In 1995, EPA notified a number of companies that sent waste to ARC, referred to as "generators," and Jack Kaplan, the former president of ARC, that they were considered PRPs with respect to the cleanup of the ARC site and the HRDD portion of the Horseshoe Road site.

The Horseshoe Road site was proposed for inclusion on the NPL in 1993, and formally placed on the NPL on September 29, 1995. The ARC facility was initially included in the description of the Horseshoe Road site, but it was removed from the NPL listing after the PRPs for ARC challenged the joint listing.

In the summer of 1997, EPA initiated a remedial investigation and feasibility study (RI/FS) to jointly characterize the nature and extent of contamination at the sites. An RI report was released in 1999. The RI evaluated groundwater, surface water, surface soils, subsurface soils, sediments and building material.

EPA is addressing the sites in separate phases, or operable units. In September 1999, a Focused Feasibility Study (FFS) was completed for Operable Unit 1 (OU1), the buildings and structures on the ADC and ARC facilities. A September 2000 Record of Decision (ROD) for OU1 called for demolition and off-site disposal of buildings and above-ground structures. On April 10, 2001, EPA completed the OU1 remedy for the Horseshoe Road site, removing the buildings and surface debris from the ADC facility.

Since 1995 when the Horseshoe Road site was first placed on the NPL, EPA has entered into several orders with various PRPs for the ARC site to perform various site tasks: to reimburse EPA for the costs of several removal actions; to undertake the OU1 remedy for the ARC site; and to complete the Operable Unit 3 (OU3) RI/FS. Under this last order, PRPs completed a combined OU3 RI/FS for both sites that served as the basis for this ROD.

Based on additional data gathered from the ARC site during the RI, together with previously obtained data, EPA proposed the ARC facility as a separate NPL site in September 2001. The site was formally placed on the NPL on September 5, 2002.

In May 2003, the OU1 remedy for the ARC site was completed.   A PRP group for the ARC site, with EPA oversight, demolished and disposed of all on-site buildings and above-ground structures, and removed several underground storage tanks discovered during the cleanup.

In September 2004, EPA signed a ROD addressing soil and groundwater identified as Operable Unit 2 (OU2). The ROD called for excavation and disposal of contaminated soil, including deep soils that acted as groundwater contaminant source material. In February 2008, EPA began work on the OU2 Remedy for the Horseshoe Road site.

In July 2007, EPA and a PRP Group for the ARC site entered onto a judicial consent decree to perform the OU2 remedial design for both the ARC site and HRDD portion of the Horseshoe Road site, and the remedial action for the ARC site. The PRPs are currently in the design phase of those actions.

The May 1999 RI report, and the May 2006 Baseline Ecological Risk Assessment are discussed below, and formed the basis for the development of the OU3 FS report and this ROD. All these documents are included in the Administrative Record for the sites.

HIGHLIGHTS OF COMMUNITY PARTICIPATION

Since the Horseshoe Road site’s placement on the NPL, EPA has worked closely with the Edison Wetlands Association (EWA), public officials and other interested and concerned members of the community. EWA received a Technical Assistance Grant (TAG) from EPA to assist in its independent efforts to communicate information about the Horseshoe Road site to the surrounding community. Public interest in both sites has remained high.

On July 21, 2008, EPA released the Proposed Plan and supporting documentation for the sediment remedy (OU3) to the public for comment. EPA made these documents available to the public in the administrative record repositories maintained at the EPA Region II office (290 Broadway, New York, New York 10007), and the Sayreville Public Library (1050 Washington Road, Parlin, New Jersey 08859). EPA published a notice of availability involving these documents in the Suburban Newspaper, and opened a public comment period on the documents from July 21, 2008 to August 20, 2008.

On August 12, 2008, EPA held a public meeting at the Sayreville Township Municipal Building, to inform local officials and interested citizens about the Superfund process, to review the planned remedial activities at the Horseshoe Road and Atlantic Resources Sites, and to respond to any questions from area residents and other attendees.

Responses to the comments received at the public meeting and in writing during the public comment period are included in the Responsiveness Summary (see Appendix V).

SCOPE AND ROLE OF OPERABLE UNIT

As with many Superfund sites, the problems at the Horseshoe Road and ARC sites are complex and, therefore, to more effectively manage the cleanup of the sites, EPA has organized the work into three operable units (OUs):

Operable Unit 1:	Demolition of buildings and above-ground structures (Completed in 2003).
Operable Unit 2:	Contaminated soil and groundwater (Clean-up work began February 2008 for Horseshoe Road; the OU2 remedy for the ARC site is currently in remedial design).
Operable Unit 3:	Marsh and River Sediment (the subject of this ROD).

OU3 addresses sediment in the adjacent Marsh and River and is the last operable unit for these sites.

SUMMARY OF SITE CHARACTERISTICS

Horseshoe/ARC Marsh Sediments

The Horseshoe Road site includes the former ADC facility, the SPD areas (allegedly used by ADC), and the HRDD area, which was used by ARC. One drainage channel collects most of the surface water from the ADC and SPD areas (please refer to Appendix I, Figure 2). This ADC/SPD drainage channel appears to provide a majority of the fresh water flow into the Marsh, and the most distinguishable surface water channel through the Marsh can be traced back to this channel.

A second drainageway begins at a small depression that approximately divides the ADC and ARC operations, travels just south of the HRDD area, and discharges into the Marsh at the base of the HRDD mound. Both sites contribute surface water flow to this HRDD drainageway.

Surface water runoff from the HRDD mound enters into the HRDD drainageway or releases directly into the Marsh. The ARC site has its own drainage swale just north of the HRDD area, and most of the surface water runoff from ARC currently travels through this swale. Unlike the other surface water routes described above, which appear to be natural water courses, portions of this swale are man-made. Surface water travels through a culvert under the MCUA right-of-way to reach the ARC swale, and water from the swale discharges to the bay north of the Marsh.

Approximately 95 Percent of the Horseshoe/ARC Marsh is dominated by Common Reed (*Phragmites*) and is considered a freshwater emergent wetland. The remaining five percent is a fringe that is an average of 25 feet wide at the edge of the Raritan River, and dominated by salt-tolerant cordgrass (*Spartina*), indicative of an intertidal wetland environment. A natural berm formed by tidal deposition separates these two wetland zones. This berm is only breached in one location where the surface water enters the River from the Marsh. Site topography, which includes the drainage channels previously described, influenced EPA to investigate the down-gradient Marsh, which is approximately 8.2 acres in size. EPA evaluated surface and subsurface sediment samples collected from the Marsh. For its studies, EPA considered surface sediments to be within the first 12 inches of the surface within the Marsh. Subsurface samples were taken from 12 to 42 inches. Reference samples were collected in an area of marsh sediments about 400 feet south of the former Crossman Dock, and these results were one of a number of data points used to screen marsh sediments for contaminants of concern. Marsh sediments were analyzed for volatile and semivolatile organic compounds, metals, pesticides and polychlorinated biphenyls (PCBs), and three contaminants of concern were identified in the Marsh and associated drainageways: arsenic; mercury; and PCBs. The reference sample results appear in Appendix II, Table 1, along with representative Horseshoe/ARC Marsh sediment data. All mercury sampling at the sites was analyzed for total mercury.

The ADC/SPD drainage channel is the most highly contaminated portion of the Marsh. PCBs are found at highest concentrations in shallow surface sediments of the channel, and at lesser concentrations within the Marsh itself and at depth. Arsenic and mercury were also generally found at their highest concentrations within the ADC/SPD drainage channel; however, these two metals were also found throughout the Marsh and at depth at elevated concentrations. In several cases, the deepest sediment samples collected (about 30 to 42 inches below the ground surface) were at concentrations greater than the reference sample results. Some arsenic concentrations were an order of magnitude greater than that found in the reference area samples.

The presence of arsenic and mercury at depth, but not PCBs, indicates that sediment deposition and burial over time was probably not a major factor in contaminant distribution to deeper sediments. A groundwater pathway for transport of contaminants from the upland site areas into the deeper sediments of the Marsh was considered as part of the OU2 RI/FS, and the OU2 ROD concluded that a groundwater transport pathway was highly unlikely for the contaminants of concern in the Marsh (arsenic, mercury and PCBs). The rate of groundwater flow through the dense clays and silts found in upland soils is very slow, and the Marsh contaminants were found to be at very low concentrations or "non-detect" in the monitoring wells furthest downgradient (nearest the Marsh). Volatile organic compounds were the groundwater contaminants that were likely to migrate to the Marsh from upland sources. (This assessment of groundwater transport mechanisms applies to River sediments as well.) The deeper distribution pattern for arsenic and mercury suggest that these contaminants may have been discharged into the Marsh in a relatively soluble form, allowing dissolved constituents to pass deeper into the marsh sediments. Subsurface geochemistry may then have decreased arsenic and mercury solubility, resulting in deposition in these deeper sediments. After reviewing the current water quality in the Marsh, the FS concluded that these deeper sediments are "stable", that is, the Marsh contaminants are not likely to be transported in groundwater, and are bound to the deeper sediments.

Raritan River Sediments

The sites are about four miles from the mouth of the Raritan River where it meets the Atlantic Ocean, and the River is approximately 2,600 feet wide at this point. This reach of the Raritan River is a tidal estuary.

The Raritan River Estuary has been identified as an impaired water under Section 303(d) of the Clean Water Act as a result of metals (including arsenic and mercury) contamination, and New Jersey has established fishing advisories within the Raritan River as a result of PCB contamination that may be found in American Eel, White Catfish, White Perch, Striped Bass, Bluefish, and Blue Claw crab.

The U.S. Army Corps of Engineers (USACE) maintains a commercial shipping channel, the “Main Channel,” along the north shore of the Raritan. For much of the 20th century, a second channel served the NL Industries/Titanium Pigments facility (“the Titanium Reach”), and a smaller extension (“the South Channel”) served Crossman Dock and other brick-related businesses in Sayreville. At one time, the South Channel was dredged to a depth of 15 feet (measured at low tide) and was 150 feet wide. Now, the South Channel is mostly silted in, with an average depth of 4.2 feet. The USACE has no plans for dredging the Titanium Reach or the South Channel, neither of which serves any commercial interests at this time. It is possible that Sayreville may consider a marina as part of its waterfront development plans; however, there are no current plans for a marina.

Pilings from the Crossman Dock are still present in the River in front of the Horseshoe/ARC Marsh. A depositional area can be found in front of the Horseshoe/ARC Marsh, between the shoreline and these pilings. Because the Marsh drains directly into this depositional area, through a breach in the berm that runs along the River, EPA sampled this area and the area around it.

Reference samples were collected from near-shore sediments up-river and down-river from the sites. Other Raritan River sediment data were also consulted to provide a better picture of the current contaminant loading in river sediments. The FS compared the site-specific reference data to results from National Lead Industries (NL) sampling events (collected in 2003 at the direction of NJDEP) for arsenic. The FS also compared the site-specific reference data to results from USACE sampling of the Main Channel (2004) for arsenic, mercury and PCBs.

The reference data in Appendix II, Table 2 presents the combined (site-specific and river-wide) sediment sampling results. The river-wide results include data from the 2004 USACE survey, which is not in the FS, but is included in the Administrative Record. The near-site river sampling areas are shown on Appendix I, Figure 3.

Surface (0 to six inches) and subsurface (six inches to 42 inches below the river bottom) sediment samples were collected. Raritan River sediment contamination was characterized by arsenic and mercury in surface and subsurface sediments. PCBs were much less frequently detected relative to the marsh sediments.

The sampling results indicate that the depositional area behind the dock pilings contains elevated levels of arsenic and mercury relative to the surrounding sediments. The surrounding sediments have contaminant levels that are more consistent with background levels for the River, as indicated by both the off-site sample results and other off-site data from the NL site and Army Corps surveys.

Based on analytical results and past site practices, it appears that contamination migrated to the Marsh and Raritan River through runoff from the sites, and groundwater transport does not appear to be a contributing mechanism to sediment contamination, though the contaminated sediments appear to be a likely continuing source of contamination to the River.

CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

Site Uses: Prior to the start of the OU1 remedy, the sites were abandoned and fenced off to the extent practicable. The sites are zoned for industrial use, similar to the current use of neighboring, occupied commercial properties. In discussions with members of the Sayreville Planning Board and Zoning Office, as well as review of the borough zoning ordinances, EPA has been advised that the properties contaminated by the two sites are zoned for economic redevelopment and light industrial usage. Both of these uses exclude residential use. Furthermore, the Borough expects that the future use of this area will be integrated into one of several long-range planning projects, either the “Main Street Bypass”, which might involve some commercial land use, or as part of an open-space shoreline redevelopment that would provide access to the Raritan River for recreational and light commercial purposes. In either case, residential re-use is not contemplated. The 8.2-acre Marsh is not suitable for commercial development and, under any of these future-use scenarios EPA expects that the Marsh will remain open space/ecological habitat.

Ground and Surface Water Uses: Groundwater underlying the sites is considered by New Jersey to be Class II-A, a source of potable water; however, no current exposure pathways to contaminated groundwater are known. Based on the very low yields measured in monitoring wells, the groundwater formations would not yield enough water for a potable well. The nearest aquifers used for drinking water are stratigraphically isolated and not threatened by the groundwater contamination from the sites.

SUMMARY OF SITE RISKS

As part of the RI/FS, EPA conducted a baseline risk assessment to estimate the current and future effects of contaminants on human health and the environment. A baseline risk assessment is an analysis of the potential adverse human health and ecological effects of releases of hazardous substances from a site in the absence of any actions or controls to mitigate such releases, under current and future land uses. The baseline risk assessment includes a human health risk assessment and an ecological risk assessment. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the results of the baseline risk assessment for the sites.

Human Health Risk Assessment

A four-step process is utilized for assessing site-related human health risks for a reasonable maximum exposure scenario: *Hazard Identification* – uses the analytical data collected to identify the contaminants of potential concern at the sites for each medium, with consideration of a number of factors explained below; *Exposure Assessment* - estimates the magnitude of actual and/or potential human exposures, the frequency and duration of these exposures, and the pathways (e.g., ingesting contaminated well water) by which humans are potentially exposed; *Toxicity Assessment* - determines the types of adverse health effects associated with chemical exposures, and the relationship between magnitude of exposure (dose) and severity of adverse effects (response); and *Risk Characterization* - summarizes and combines outputs of the exposure and toxicity assessments to provide a quantitative assessment of site-related risks. The risk characterization also identifies contamination at concentrations that exceed acceptable levels, defined by the NCP as an excess lifetime cancer risk greater than 1×10^{-6} to 1×10^{-4} or a Hazard Index greater than 1.0; contaminants at these concentrations are considered chemicals of concern (COCs) and are typically those that will require remediation at the sites. Also included in this section is a discussion of the uncertainties associated with these risks.

Hazard Identification

In this step, the chemicals of potential concern (COPCs) in each medium were identified based on such factors as toxicity, frequency of occurrence, fate and transport of the contaminants in the environment, concentrations, mobility, persistence, and bioaccumulation. Analytical information that was collected to determine the nature and extent of contamination revealed the presence of arsenic at the sites at concentrations of potential concern. Based on this information, the risk assessment focused on surface water, sediment, and shellfish contaminants that may pose significant risk to human health.

A comprehensive list of all COPCs can be found in the BHHRA, which consists of documents entitled "Final Baseline Human Health Risk Assessment – Horseshoe Road Complex Site" (EPA , October 6, 1999) and "Final Human Health Risk Assessment Addendum Horseshoe Road Complex Site" (EPA, October 31, 2000). These documents are available in the Administrative Record file. Only the COCs, or those chemicals requiring remediation at the sites, are listed in Appendix II, Table 3 of this ROD.

Exposure Assessment

Consistent with Superfund policy and guidance, the BHHRA is a baseline human health risk assessment and, therefore, assumes no remediation or institutional controls to mitigate or remove hazardous substance releases. Cancer risks and noncancer hazard indices were calculated based on an estimate of the reasonable maximum exposure (RME) expected to occur under current and future conditions at the sites. The RME is defined as the highest exposure that is reasonably expected to occur at the sites. For those contaminants for which the risk or hazard exceeded the acceptable levels, the central tendency estimate (CTE), or the average exposure, was also evaluated.

The sites are currently zoned for commercial use, although there are residential properties in the vicinity of the sites. According to recent information from Sayreville, it is anticipated that the future land use for this area will remain consistent with its current use or be used for recreational activities. The BHHRA evaluated potential risks to populations associated with both current and potential future land uses.

Exposure pathways were identified for each potentially exposed population and each potential exposure scenario for the surface water, sediment, and shellfish. Exposure pathways assessed in the BHHRA for the surface water and sediment included ingestion and dermal contact by residents living nearby the sites, on-site workers, and recreational visitors/trespassers. In addition, ingestion of shellfish through recreational/subsistence fishing was also evaluated. A summary of the exposure pathways that were associated with elevated risks or hazards can be found in Appendix II, Table 4. Typically, exposures are evaluated using a statistical estimate of the exposure point concentration, which is usually an upper-bound estimate of the average concentration for each contaminant, but in some cases may be the maximum detected concentration. A summary of the exposure point concentrations for the COCs in each medium can be found in Appendix II, Table 3, while a comprehensive list of the exposure point concentrations for all COPCs can be found in the BHHRA.

Toxicity Assessment

Under current EPA guidelines, the likelihood of carcinogenic risks and noncancer hazards due to exposure to site chemicals are considered separately. Consistent with current EPA policy, it was assumed that the toxic effects of the site-related chemicals would be additive. Thus, cancer and noncancer risks associated with exposures to individual COPCs were summed to indicate the potential risks and hazards associated with mixtures of potential carcinogens and noncarcinogens, respectively.

Toxicity data for the human health risk assessment were provided by the Integrated Risk Information System (IRIS) database, the Provisional Peer Reviewed Toxicity Database (PPRTV), or another source that is identified as an appropriate reference for toxicity values consistent with EPA's directive on toxicity values. This information is presented in Appendix II, Table 5 (noncancer toxicity data summary) and Appendix II, Table 6 (cancer toxicity data summary). Additional toxicity information for all COPCs is presented in the BHHRA.

Risk Characterization

Noncarcinogenic risks were assessed using a hazard index (HI) approach, based on a comparison of expected contaminant intakes and benchmark comparison levels of intake (reference doses, reference concentrations). Reference doses (RfDs) and reference concentrations (RfCs) are estimates of daily exposure levels for humans (including sensitive individuals) that are thought to be safe over a lifetime of exposure. The estimated intake of chemicals identified in environmental media (*e.g.*, the amount of a chemical ingested from contaminated drinking water) is compared to the RfD or the RfC to derive the hazard quotient (HQ) for the contaminant in the particular medium. The HI is obtained by adding the hazard quotients for all compounds within a particular medium that impacts a particular receptor population.

The HQ for oral and dermal exposures is calculated as below. The HQ for inhalation exposures is calculated using a similar model that incorporates the RfC, rather than the RfD.

HQ = Intake/RfD

Where: HQ = hazard quotient
Intake = estimated intake for a chemical (mg/kg-day)
RfD = reference dose (mg/kg-day)

The intake and the RfD will represent the same exposure period (i.e., chronic, subchronic, or acute).

As previously stated, the HI is calculated by summing the HQs for all chemicals for likely exposure scenarios for a specific population. An HI greater than 1.0 indicates that the potential exists for noncarcinogenic health effects to occur as a result of site-related exposures, with the potential for health effects increasing as the HI increases. When the HI calculated for all chemicals for a specific population exceeds 1.0, separate HI values are then calculated for those chemicals which are known to act on the same target organ. These discrete HI values are then compared to the acceptable limit of 1.0 to evaluate the potential for noncancer health effects on a specific target organ. The HI provides a useful reference point for gauging the potential significance of multiple contaminant exposures within a single medium or across media. A summary of the noncarcinogenic risks associated with these chemicals for each exposure pathway is contained in Appendix II, Table 7.

It can be seen in Appendix II, Table 7 that the HI for noncancer effects due to potential exposure to arsenic in surface water and sediment is 2.1 for the youth resident exposed to marsh sediments and surface water and 1.1 for the youth resident exposed to Raritan River sediment and surface water. The noncancer HI is 2.6 for future adult residents exposed to arsenic in marsh sediments and surface water and is 1.5 for future adult residents exposed to Raritan River sediment, surface water and shellfish. The noncancer HI for future child residents due to exposure to marsh sediment and surface water and Raritan River sediment and surface water is 16 and 8, respectively. The noncarcinogenic hazards for these populations were attributable primarily to arsenic and all are above the acceptable EPA value of 1.

For carcinogens, risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a carcinogen, using the cancer slope factor (SF) for oral and dermal exposures and the inhalation unit risk (IUR) for inhalation exposures. Excess lifetime cancer risk for oral and dermal exposures is calculated from the following equation, while the equation for inhalation exposures uses the IUR, rather than the SF:

Risk = LADD x SF

Where: Risk = a unitless probability (1×10^{-6}) of an individual developing cancer
LADD = lifetime average daily dose averaged over 70 years (mg/kg-day)
SF = cancer slope factor, expressed as [1/(mg/kg-day)]

These risks are probabilities that are usually expressed in scientific notation (such as 1×10^{-4}). An excess lifetime cancer risk of 1×10^{-4} indicates that one additional incidence of cancer may occur in a population of 10,000 people who are exposed under the conditions identified in the assessment. Again, as stated in the NCP, the acceptable risk range for site-related exposure is 10^{-6} to 10^{-4}.

Results of the BHHRA presented in Appendix II, Table 8 indicate that future adult residents (3.9×10^{-4} Marsh; 2.5×10^{-4} Raritan River) and future child residents (6.1×10^{-4} Marsh; 3.1×10^{-4} Raritan River) exceed the acceptable EPA risk range due to exposure to arsenic in surface water, sediment, and shellfish.

In summary, arsenic in surface water, sediment, and shellfish contribute to unacceptable risks and hazards to receptor populations that may use the sites. The non-cancer hazards and cancer risks from all COPCs can be found in the BHHRA.

The response action selected in the ROD is necessary to protect the public health or welfare and the environment from actual or threatened releases of contaminants into the environment.

Uncertainties

The procedures and inputs used to assess risks in this evaluation, as in all such assessments, are subject to a wide variety of uncertainties. In general, the main sources of uncertainty include:

- environmental chemistry sampling and analysis

- environmental parameter measurement
- fate and transport modeling
- exposure parameter estimation
- toxicological data.

Uncertainty in environmental sampling arises in part from the potentially uneven distribution of chemicals in the media sampled. Consequently, there is significant uncertainty as to the actual levels present. Environmental chemistry-analysis error can stem from several sources including the errors inherent in the analytical methods and characteristics of the matrix being sampled.

Uncertainties in the exposure assessment are related to estimates of how often an individual would actually come in contact with the chemicals of concern, the period of time over which such exposure would occur, and in the models used to estimate the concentrations of the chemicals of concern at the point of exposure.

Uncertainties in toxicological data occur in extrapolating both from animals to humans and from high to low doses of exposure, as well as from the difficulties in assessing the toxicity of a mixture of chemicals. These uncertainties are addressed by making conservative assumptions concerning risk and exposure parameters throughout the assessment. As a result, the risk assessment provides upper-bound estimates of the risks to populations near the sites, and is highly unlikely to underestimate actual risks related to the sites.

More specific information concerning public health risks, including a quantitative evaluation of the degree of risk associated with various exposure pathways, is presented in the risk assessment report.

Actual or threatened releases of hazardous substances from these sites, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare or the environment.

Ecological Risk Assessment

During the original RI (1999), a Screening Level Ecological Risk Assessment (SLERA) was prepared for the Horseshoe Road/ARC sites, to determine which contaminants and exposure pathways presented ecological risks based on conservative assumptions. The SLERA considered upland, Marsh and River ecological risks. Receptor species selected to represent the different habitats and trophic levels of the sites were the red-tailed hawk, short-tailed shrew, marsh wren, spotted sandpiper, green frog, fiddler crab, and the benthic invertebrate community. The assessment endpoint for these receptors in the SLERA was the disruption of ecological community structure by the reduction of ecological populations.

Regarding the measurement endpoints for the SLERA, food chain risks were estimated for the modeled receptors (red-tailed hawk, short-tailed shrew, marsh wren, spotted sandpiper) by comparing estimated exposure levels with ecologically-based toxicity reference values. The risks to the green frog and fiddler crab were evaluated by comparing surface water concentrations to aquatic toxicological benchmarks. The comparison of sediment and surface water contaminant concentrations to ecologically-based screening values was conducted to determine risks to benthic invertebrates. Also included in the assessment were the results of biota sampling from EPA's Environmental Response Team (ERT). ERT collected and analyzed tissue from small mammals and fiddler crabs from these sites. These data showed potential contaminant migration off site and into the food chain. Consequently, a SLERA Addendum was completed to collect additional samples in the Marsh and the Raritan River. The SLERA Addendum was completed in 2002. Forage fish samples were collected to estimate contaminant concentrations in fish tissue. Toxicity tests were conducted at five sampling locations using a 28-day chronic bioassay.

The SLERA and the SLERA Addendum identified the potential for ecological risks for all the representative receptors evaluated with exposure to contaminants in sediment, surface water, and surface soil. After reviewing the SLERA work, EPA concluded that a Baseline Ecological Risk Assessment (BERA) was warranted.

A four-step process is utilized for assessing site-related ecological risks for a reasonable maximum exposure scenario:

> **Problem Formulation** - a qualitative evaluation of contaminant release, migration, and fate; identification of COPCs, receptors, exposure pathways, and known ecological effects of the contaminants; and selection of endpoints for further study.
>
> **Exposure Assessment** - a quantitative evaluation of contaminant release, migration, and fate; characterization of exposure pathways and receptors; and measurement or estimation of exposure point concentrations.

Ecological Effects Assessment - literature reviews, field studies, and toxicity tests, linking contaminant concentrations to effects on ecological receptors.

Risk Characterization - measurement or estimation of both current and future adverse effects.

Problem Formulation/Exposure Assessment

As with the human health risk assessment, the BERA reviewed all potential site contaminants. The assessment endpoints in the BERA focused on the following Marsh and River ecosystems:

- **aquatic macroinvertebrate community** abundance and population production in Marsh sediment, relying upon laboratory testing of sediment toxicity using a sensitive and representative aquatic macroinvertebrate (*Lumbriculus variegatus,* blackworm) as the measurement endpoint;
- **terrestrial invertebrate community** abundance and population in the Marsh sediment, relying upon laboratory testing of sediment toxicity using a sensitive and representative terrestrial invertebrate (*Eisenia fetida*, earthworm) as the measurement endpoint;
- **estuarine fish population** abundance and community structure in the Raritan River, relying upon measured concentrations of COPCs in the water column compared with state water quality standards and measured COPCs in estuarine fishes of the Raritan compared with literature-based effect-level thresholds as measurement endpoints; and
- **wildlife population** abundance in the Marsh and the River, relying upon modeled dietary doses of COPCs based on measured concentrations of COPCs in prey organisms and Marsh and River sediments, compared with toxicity reference values.

For the wildlife population assessment, a set of indicator species were selected to represent different functional groups that might use the Marsh or River, such as mammals that eat insects, or birds of prey that rely on fish. Representative wildlife species for the Marsh were the short-tailed shrew, muskrat, marsh wren, and red-tailed hawk. The wildlife species selected for the Raritan River included the osprey and the herring gull.

Ecological Effects Assessment

The BERA relied upon both site-specific quantitative effects studies and site-specific data (where available) compared to literature-derived values to evaluate the four assessment endpoints.

Toxicity Testing. Site-specific sediment toxicity tests were the primary measurement endpoints for assessment of both the aquatic macroinvertabrate and terrestrial invertabrate communities, and in each case the toxicity testing only considered Marsh sediments. In addition to the work in the BERA, sediment toxicity testing was performed for River sediments as described in the SLERA Addendum, discussed below.

- **Blackworm and Earthworm (Marsh sediment) toxicity testing.** These toxicity tests evaluated survival and biomass reduction endpoints, evaluating lethal and sub-lethal (chronic) effects on the indicator species. Significant reduced survival and biomass were found for the blackworm and significant reduced biomass was found for the earthworm for exposure to sediments collected at several of the 10 sampling stations. The BERA compared sediment contaminant levels in each of the 10 sampling locations (and three reference locations) to the measurement endpoints to identify apparent effects threshold (AET) values for 18 different contaminants, and then used these AET values to assess the risks to invertebrates. To be conservative, the lowest AET for each target chemical was selected, including 31.6 ppm for arsenic, 3.6 ppm for mercury, and 2.2 ppm for total PCBs. AETs for other chemicals were also calculated and appear in the BERA. A strong correlation between sediment concentration and both survival and biomass reduction could be identified: higher contaminant concentrations correlated with higher mortality and greater biomass reduction. Overall, the blackworm was determined to be a substantially more sensitive species during the toxicity testing, and all these AETs derive from blackworm data.

- **SLERA (River sediment) toxicity testing.** A 28-day sediment toxicity test using the saltwater test species *Leptochirus* plumulosus (an amphipod) showed significant reduced survival (43 percent) as compared to the survival (82 percent) at a reference station at sediment sampling location RSD07, one of four locations tested. The other three locations had survival results similar to the reference location. Location RSD07, near the discharge point for the SPD/ADC channel, also had the lowest measurements for growth and reproduction (sub-lethal, or chronic) endpoints. The concentrations of arsenic and mercury at RSD07 were 194 ppm and 2.6 ppm, respectively. These findings suggest that there may be potential risk to benthic organisms from contaminated River sediment at concentrations similar to these.

Assessment of Estuarine Fishes. This work was performed during the SLERA and involved comparison of COPC concentrations in the surface water against screening benchmarks, and comparison of COPC concentrations in fish/crab tissue with whole-body residue effects levels. This screening assessment indicated that there was a very low likelihood of adverse effects to estuarine fishes from COPCs in surface water. While New Jersey has established fishing advisories within the Raritan River as a result of PCB levels that may be found in American Eel, White Catfish, White Perch, Striped Bass, Bluefish, and Blue Claw crab, locally collected crabs and forage fish have not demonstrated elevated concentrations of COPCs during several different sampling events. The most recent sampling event (crabs and killifish) was associated with the BERA supplemental investigations in 2004.

Wildlife Assessment. Food-web exposure models were developed for bird and mammal species that might frequent the site, to assess site-specific exposures that might occur. Then exposure assessments attempt to link potential contaminant exposure-point concentrations to potential adverse effect in selected receptors. Exposure assessments were performed for each of the indicator species (the short-tailed shrew, muskrat, marsh wren, and red-tailed hawk for the Marsh and the osprey and herring gull for the River). The assessments relied on site-specific inputs for assessing potential exposure (sediment concentrations and measured or extrapolated food source concentrations) and then literature values for exposure parameters (body weight, diet, home range size, etc.) for each of the indicator species.

Marsh - Food web model results for short-tail shrew (representing mammals that may feed on insects) suggest arsenic, mercury and PCBs, and possibly copper are the primary drivers of ecological risk, and that hazard quotients (a quantification of risk) were elevated above the reference areas across the Marsh. The magnitude of hazard quotient values varied across the Marsh generally in relation to contaminant concentrations. Results for muskrat, (mammalian herbivore), were averaged over the entire marsh based upon a wider home range. Arsenic and mercury appear to be the primary contaminants of concern for muskrat, with elevated hazard quotients relative to the reference area. For the marsh wren (representing insect-eating birds), mercury appeared to be the primary risk driver, along with arsenic and chromium. As with the mammalian indicator species, the magnitude of risk could be correlated to contaminant concentrations, with higher hazard quotients for stations near the ADC/SPD channel. Finally, results for the red-tailed hawk (carnivorous bird), that may prey on small mammals within the marsh, did not manifest a likely adverse ecological effect from foraging on the site.

River - The food-web modeling of the herring gull and osprey indicated little likelihood of risks associated with contaminated sediment and surface water in the Raritan River.

In summary, potential adverse effects on bird and mammal receptor species may be associated with the elevated contaminant concentrations in the Marsh sediment. The Marsh sediment was also found to pose potential adverse effects on the growth of aquatic and terrestrial invertebrates. While several other COPCs were identified by the wildlife assessment, arsenic, mercury and PCBs were the predominant COPCs for ecological receptors. Beyond a limited benthic community assessment, which indicated some toxicity in sediments probably associated with arsenic and mercury, the ecological risk assessment attributed little likelihood of a site-specific effect to receptors in the Raritan.

Uncertainties

As with the human health risk assessment, procedures and inputs used to assess risks in this ecological evaluation are subject to a wide variety of uncertainties. Uncertainties are inherent in the collection and analysis of environmental samples, and can be compounded when sampling biota.

With regard to toxicity testing, the BERA assumed that lethal and sub-lethal effects observed were derived exclusively from chemical concentrations in the sediments. A number of other factors may influence both survival and growth of the blackworm and earthworm in site sediments in a laboratory setting, such as moisture content or grain particle size distribution, or the particular site setting that might not be ideally suited to the indicator species. In addition, the data sets for toxicity testing were relatively small, particularly in the case of the SLERA testing of River sediments using amphipods, and small data sets introduce higher levels of uncertainty into the results.

With regard to the assessment of estuarine fish tissue, a reliable assessment of this kind is hampered by several factors. The extent of sediment contamination in the Raritan that is demonstratively attributable to the sites, generally about two acres, is small, and the level of "background" contamination with site COPCs within the estuary is relatively high. The habitat ranges of estuarine fishes that have been sampled is not confined to the two-acre area. In addition, because the assessment area is small, the sample size (number of individuals collected for analysis) has generally been too small for reliable statistical analysis of the data.

Food-web modeled exposure assessments are a satisfactory method of assessing risk to wildlife receptors, but require a large and in some cases speculative set of assumptions about various life-cycle factors for targeted species, such as the size of a foraging range or the variability of body weights. The BERA identified a number of potential sources of uncertainty for the wildlife assessments, including body mass and intake rate parameters, diet composition, area use (the site size relative to the home range), measured COPC concentrations in environmental media and food sources, and COPC bioavailability. Another area of uncertainty are the literature-derived values for ecotoxicity, where toxicity thresholds for test species for particular contaminants can vary widely and need to be extrapolated to a particular local setting.

The BERA discusses several additional areas of uncertainty, including the levels of contamination found in the reference areas, and the reliability of extrapolating the responses of individuals to the level of a population.

REMEDIAL ACTION OBJECTIVES

Remedial action objectives are specific goals to protect human health and the environment. These objectives are based on available information and standards such as applicable or relevant and appropriate requirements (ARARs) and risk-based levels established in the risk assessment.

The following remedial action objectives for contaminated sediments address the human health risks and environmental concerns at the Horseshoe Road and ARC sites:

Sediments - Marsh

- Reduce human health risks from exposure, including ingestion, inhalation and dermal contact, to contaminants in the surface and sub-surface sediments to acceptable levels.

- Reduce risks to environmental receptors from exposure to contaminants in the sediments to acceptable levels.

- Minimize the migration of contaminated sediments to the Raritan River through surface water runoff or flooding.

Sediments - River

- Reduce the potential for human health risks from exposure to river sediments within the low-tide mudflat in front of the sites, through ingestion or dermal contact, to acceptable levels.

- Reduce exposure to sediments deposited in the River adjacent to the sites with highly elevated contaminant concentrations that contribute to the degradation of the Raritan River Estuary, and result in risks to ecological receptors, including benthic aquatic organisms, shellfish, fish, birds and mammals.

REMEDIATION GOALS

Sediments - Marsh

The Remediation Goals discussed below balance several factors in addressing arsenic, mercury, and PCBs. EPA has identified cleanup criteria only for arsenic and mercury, because when these criteria are met, risks from other COCs, which are co-located, would be addressed as well (see Appendix I, Figures 3 & 6). Furthermore, given the distribution of PCBs in the Marsh and River sediments, by addressing arsenic and mercury, PCBs will also be remediated (see Figures 3 & 7).

In developing Remediation Goals for marsh sediments, EPA considered sediment risk levels for each COC identified in the BHHRA and BERA, available background values, and other ecological receptor reference values such as sediment quality guidelines adopted by NJDEP.

The BHHRA presented preliminary remediation goals (PRGs) for exposure to arsenic in sediments for the three receptor populations. The values presented in Appendix F of the BHHRA were calculated for a hazard index of 1 and a cancer risk of 10^{-4}. Typically, PRGs are presented as a range of values that span the acceptable risk range. Appendix II, Table 9 presents the PRGs that are associated with the acceptable hazard index of 1 and cancer risk range, as well as calculated background values and ecologically relevant values. These values were taken into consideration when selecting the appropriate remediation goal.

Identifying a Remediation Goal for arsenic in the Marsh provides the broadest range of factors to consider. From the starting point of direct ecological effects to receptors within the Marsh, the BERA sediment toxicity testing results were used to calculate site-specific Apparent Effects Thresholds (AETs) of 32 mg/kg and 1,050 mg/kg (biomass reduction in blackworms and earthworms, respectively). In addition, data from the wildlife assessments in the BERA allowed for the derivation of Lowest Observed Apparent Effects Levels (LOAELs) for higher trophic species, calculated to result in a hazard quotient of one, ranging from 183 mg/kg (muskrat)* to 1,420 mg/kg (marsh wren). After considering screening values used by NJDEP and the recommendations of the other Natural Resource Trustees, EPA has identified 32 mg/kg as the Remediation Goal for the benthic zone of the Marsh (within the first foot of the marsh sediments). Applying this Remediation Goal to the surface sediments addresses most of the remedial action objectives, and in particular, satisfies the Agency's desire to minimize the Marsh as a continuing source of contamination to the Raritan.

The surface sediment remediation goals were selected to be protective for ecological receptors and for human exposure, and EPA expects that addressing sediment contamination within the first foot of the Marsh will be protective for most potential receptors; however, after considering several factors described below, EPA has identified a second Remediation Goal of 160 mg/kg arsenic for deeper marsh sediments (below the benthic zone).

Through biotic activity such as burrowing, animals such as muskrat can be exposed to sediments deeper than one foot and bring these sediments to the surface. The site-specific exposure assessment for muskrat identified a LOAEL concentration of 183 mg/kg for arsenic; this concentration was one of the factors considered by the Region for assessing this deep-sediment Remediation Goal. This deep sediment Remediation Goal, which is below the muskrat LOAEL, should also protect other higher trophic species, presuming that the remediated Marsh would develop from its current state as a degraded Phragmites monoculture to support a more robust, high quality habitat.

In addition, EPA concluded that the remedial action objectives would be very difficult to achieve over the long term by only

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* Different values for the Muskrat LOAEL and NOAEL were identified in the Proposed Plan. The correct values appear in the FS Report and in this document.

addressing the surface sediments. The uncertainties of the setting cannot be accounted for by only addressing the surface sediments. These uncertainties include flooding and scouring from peak storm events, and the possibility that the primary ADC stream channel may meander over time, resulting in newly exposed sediments. Deeper sediments are also thought to represent a contamination reservoir, whereby surface sediments in the marsh or the river could potentially be recontaminated by these sediments. The 160 mg/kg-Remediation Goal for arsenic in the marsh is meant to address the deeper sediments that act as a potential continuing source.

EPA further concluded that sediments deeper than about 30 inches were not accessible even to phragmites roots, the predominant Marsh plant species; therefore, the maximum remediation depth to satisfy the remedial action objectives is 30 inches except for the channel areas. The remediation depth considered in stream channels is deeper (up to 42 inches) to account for higher erosion potential. The Remedial Investigation concluded that sediments in the Marsh are relatively stable, and become more stable with depth (that is, the deeper sediments themselves are unlikely to be moved without human intervention or a severe weather disturbance, and the contaminants within the deeper sediments are bound tightly to sediment particles). Addressing surface sediments and deeper sediments in the Marsh as described above is expected to leave some contamination, even contamination in excess of 160 mg/kg arsenic, at depths greater than 30 inches while still satisfying the remedial action objectives.

EPA’s National Remedy Review Board, in reviewing Region 2's remedial plans for OU3, recommended that the Region further evaluate one additional contaminant migration pathway: the groundwater interaction between shallow and deep sediments within the Marsh, and whether any contaminated sediments that are left in place at depth might recontaminate newly placed sediments to levels that would not be protective, through remobilization and transport of deeper sediment contamination. Based upon the Region's current understanding, remobilization and transport of deeper sediment contamination is unlikely; however, further studies during the forthcoming remedial design for the selected Marsh remedy will further clarify this issue.

Applying a similar approach to developing a Remediation Goal for mercury, from the starting point of direct ecological effects to receptors within the Marsh, the sediment toxicity testing in the Marsh allowed for the development of site-specific AETs of 3.6 mg/kg and 15.5 mg/kg (biomass reduction in blackworms and earthworms, respectively). Data from the wildlife assessments in the BERA allowed for the derivation of LOAELs for higher trophic species, including 24 mg/kg (muskrat) and 8.7 mg/kg (marsh wren). After considering the available information, EPA identified 2.0 mg/kg total mercury as the Remediation Goal in the surface sediments, using the Severe Effects Level (SEL) adopted by NJDEP from the Ontario Ministry of the Environment, rather than the lowest of the site-specific values, because of the potential for bioaccumulation with mercury, and because of a desire to eliminate releases to the Raritan (discussed in more detail, below). Given the sensitivity of ecological receptors to mercury in the environment, EPA considered a lower value, such as NJDEP's Effects Range-Median of 0.71 mg/kg; however, since EPA's Remediation Goal is just above background levels, lower levels may not be attainable. EPA did not identify a separate Remediation Goal for deeper mercury contamination, expecting that actions to address arsenic would also address deeper mercury that might become exposed.

Sediments - Raritan River

By addressing Marsh sediments, the OU3 remedial action would address a continuing source of contamination to the River. However, because much of the lower Raritan River system sediments are contaminated with arsenic, mercury and PCBs, and the sites contribute some incremental part to that sediment contamination, a river response is also appropriate. This is particularly important for mercury and PCBs, because while the site footprint (where elevated levels in River sediments can clearly be attributable to releases from the sites) is less than three acres and is probably too small to result in quantitative food-chain level affects, the overall contribution of the sites to the lower Raritan ecosystem cannot be ignored. EPA's remedial approach for addressing both Marsh and River sediments is consistent with the New York/New Jersey Harbor Estuary Program's efforts to protect the estuary. The Harbor Estuary Program's Comprehensive Conservation and Management Plan (CCMP) recommends using available information to help set priorities for the clean closure or remediation of sites contributing contamination to the Harbor/bight. In addition, the CCMP also indicates that, even in light of elevated sediment contamination levels through the region, EPA and other responsible agencies should take appropriate steps to remediate known areas of highly contaminated sediments that are contributing to human health and ecological risks. Consistent with this approach, NJDEP has stated that it plans to evaluate other contaminated sites along the Raritan River that are also contributing incrementally to contamination in the Raritan Estuary, and Remediation Goals that EPA and the

State developed together for this ROD will be considered by the State for those sites.

While PCBs can be found in sediment throughout the River from multiple sources, the site-related footprint of PCB contamination is much smaller and is within the footprint for mercury and arsenic; therefore, EPA only developed chemical-specific sediment cleanup criteria for mercury and arsenic. The criteria for mercury is 2 mg/kg, and for arsenic, 100 mg/kg. These values offer the best balance between several factors. Blue crab and estuarine fish collected near the sites do not appear to be adversely affected by the area of very high sediment contamination found in the River adjacent to the sites. The absence of affects on higher trophic species taken from the site sediment depositional area needs to be balanced against the results of the amphipod chronic sublethal bioassay study, which suggests a LOAEL of 194 mg/kg for arsenic and 2.6 mg/kg for mercury. NJDEP has identified marine/estuarine sediment quality screening guidelines, where direct toxic affects or food-chain affects can be expected to riverine receptors, and the near-shore sediments exceed these screening values (for arsenic, mercury and PCBs) by several orders of magnitude. EPA considered using NJDEP's Effects Range-Medium (70 mg/kg for arsenic, 0.71 mg/kg mercury) as Remediation Goals, but given the background levels in the Raritan River Estuary, lower levels would not be attainable.

EPA expects that any areas of the River remediated during OU3 will be recontaminated to levels similar to the reference values identified in Appendix II, Table 2.

DESCRIPTION OF ALTERNATIVES

CERCLA requires that each remedial alternative be protective of human health and the environment, be cost effective, comply with other statutory laws, and utilize permanent solutions and alternative treatment technologies and resource recovery technologies to the maximum extent practicable. In addition, the statute includes a preference for the use of treatment as a principal element for the reduction of toxicity, mobility or volume of hazardous substances. Remedial alternatives for the Horseshoe Road site and ARC site are presented below.

Upland soil contamination at the two sites could be addressed as separate problems, because the contaminants and contaminated areas are distinct and in most cases, it is possible to designate contaminants as being attributed to one site or the other. Separate remedial alternatives could not be developed for the sediments, because constituents that might be attributable to a particular facility's operation have become intermixed in the sediments. A joint remedial approach is necessary for sediments; however, because the remedial alternatives address two separate NPL sites, costs for remedial alternatives have been divided in half and attributed to each site. This is an artificial allocation for administrative reasons, and is not a basis for liability allocation between the two sites. That allocation has not been determined at this point.

EPA is required to evaluate a wide array of remedial technologies during the RI/FS and to give preference to remedies that involve treatment as a principal element, to the extent practicable. Given the conditions identified in the OU3 sediments, the FS developed range of remedial technologies; however, none of the technologies that rely on treatment to permanently and significantly reduce the volume, toxicity or mobility of the site contaminants as a principal element were considered appropriate to carry beyond the screening stage.

DESCRIPTION OF MARSH ALTERNATIVES

Common Elements

Many of these alternatives include common components. With regard to the upland portions of the two sites, the FS assumes that the OU2 remedies would eliminate these areas as ongoing sources of contamination to sediments. It is expected that OU2 remedies would be performed prior to, or at least concurrently with, implementation of the active remedial alternatives evaluated below.

As discussed previously, EPA has identified different remedial goals to address surface and subsurface sediments to satisfy the remedial action objectives for the Marsh. The FS went further, dividing the deeper zone into three zones based on contaminant levels and distance from the stream channel. The first zone is targeted for the deepest excavation and encompasses an area within 20 feet of the channel. This zone tends to be the most contaminated, and also has the greatest potential for erosion. The second is characterized by arsenic contamination above 1,050 mg/kg (which is based on the site-specific AET for biomass reduction in earthworms). The third zone is characterized by levels between 1,050 mg/kg and EPA's remediation goal of 160 mg/kg for arsenic. The alternatives presented in the FS address these zones to varying degrees with several technologies.

The remedial alternatives also address marsh sediments to varying depths, up to 42 inches below the marsh surface. EPA concluded that sediment contamination deeper than 42 inches would be inaccessible under current conditions, and would remain inaccessible in the future, assuming that post-remedy topography is similar to current conditions.

For remedial alternatives that include excavation of sediments, contaminated sediments would be dewatered on site and transported off-site for disposal at an appropriate land disposal facility. Based on current information, treatment would not be required prior to disposal of marsh sediments.

For all alternatives except M1 (No Action), some wetlands will be adversely affected. Each of these alternatives will require wetlands restoration and/or off-site mitigation of compromised wetland resources that are not restored.

Because any combination of remedial alternatives are expected to result in some contaminants remaining on the sites above levels that would allow for unrestricted use, five-year reviews will be conducted, unless determined otherwise. In addition, while the land is currently wetlands and could not be used without extensive landfilling, institutional controls such as a deed notice, would be appropriate to prevent a change of land use in the future.

Please refer to Appendix I, Figure 4 for a simplified depiction of each Marsh alternative.

Alternative M1: No Action

Estimated Capital Cost:	$0
Estimated Operation & Maintenance (O&M) Cost:	$0
Estimated Present Worth Cost:	$0

Estimated Construction Time frame:	None
Area excavated/backfilled:	0.0 acres
Area capped:	0.0 acres

Regulations governing the Superfund program expect that the “no action” alternative will be evaluated to establish a baseline for comparison. Under this alternative, EPA would take no further action at either site to prevent exposure to contaminated sediments. Institutional controls, such as a deed notice, would not be implemented to restrict future site use. Engineering controls would not be implemented to prevent site access or exposure to site contaminants. Existing security fences would remain present in upland areas, but they would not be monitored or maintained.

Alternative M2: Channel Excavation/Armored, Thin Cover and Monitored Natural Recovery

Horseshoe Road Site Costs	
Estimated Capital Cost:	$3,550,000
Estimated O&M Cost:	$275,850
Estimated Present Worth Cost:	$3,700,000

ARC Site Costs	
Estimated Capital Cost:	$3,550,000
Estimated O&M Cost:	$275,850
Estimated Present Worth Cost:	$3,700,000

Estimated Construction Time frame:	3 months
Area excavated/backfilled:	0.3 acres
Area capped:	4.6 acres

Under this alternative, the stream channel would be dredged to a depth of three feet within a 20 foot-wide corridor the length of the SPD/ADC drainage, a total of approximately 2,000 cubic yards of material. The channel would then be backfilled to the original contour. Because of the high levels of contaminants in these sediments, Alternative M2 includes the establishment of an embedded channel armored with stone to prevent erosion and lateral movement. The marsh area outside the stream corridor with arsenic levels above 160 mg/kg would be covered with a thin cap (approximately six inches). The cap would be constructed in such a way as to allow for the re-establishment of a wetland on top of the cap. This alternative relies on natural sedimentation processes to bury marsh sediments that have arsenic contamination above 32 mg/kg but below the 160 mg/kg, and would be monitored to assure that the reduction in surface soil concentrations eventually achieves the overall site goals.

Long-term operation and maintenance (O&M) of the cap and armored channel would be required. Institutional controls, such as a deed notice, will be required to prevent disruption of the capped area.

Alternative M3: Channel Excavation, Surficial Hot Spot Removal and Monitored Natural Recovery

Horseshoe Road Site Costs	
Estimated Capital Cost:	$3,835,000
Estimated O&M Cost:	$275,850
Estimated Present Worth Cost:	$4,000,000

ARC Site Costs
Estimated Capital Cost: $3,835,000
Estimated O&M Cost: $275,850
Estimated Present Worth Cost: $4,000,000

Estimated Construction Time frame: 3 months
Area excavated/backfilled: 2.2 acres
Area capped: 0.0 acres

Under this alternative, the stream channel would be dredged to a depth of three feet within a 20 foot-wide corridor along the length of the SPD/ ADC drainage, and the marsh area outside the stream corridor with arsenic levels above 1,050 mg/kg would be excavated to a depth of one foot (a total excavation of approximately 4,883 cubic yards). The excavated areas would then be backfilled to the original contour. This alternative relies on natural sedimentation processes to bury marsh sediments with arsenic contamination above 32 mg/kg but below 1,050 mg/kg, and would be monitored to assure the reduction achieves the overall site goals.

Institutional controls, such as a deed notice, would be required to prevent future disruption of the recovered area.

Alternative M4: Channel Excavation, Shallow Hot Spot Removal and Thin Cover

Horseshoe Road Site Costs
Estimated Capital Cost: $7,355,000
Estimated O&M Cost: $275,850
Estimated Present Worth Cost: $7,500,000

ARC Site Costs
Estimated Capital Cost: $7,355,000
Estimated O&M Cost: $275,850
Estimated Present Worth Cost: $7,500,000

Estimated Construction Time frame: 3 months
Area excavated/backfilled: 2.2 acres
Area capped: 3.8 acres

Under this alternative, the stream channel would be dredged to a depth of three feet within a 20 foot-wide corridor along the SPD/ADC drainage, and the marsh area outside the stream corridor containing arsenic above 1,050 mg/kg would be excavated to a depth of two feet (a total excavation of approximately 7,766 cubic yards). The excavated areas would then be backfilled to the original contour. Marsh sediments that are above 32 mg/kg of arsenic or 2 mg/kg of mercury, but below 1,050 mg/kg of arsenic would be covered with a thin cap (approximately six inches). The cap would be constructed in such a way as to allow for the re-establishment of a wetland on top of the cap.

Long-term O&M of the cap would be required. Institutional controls, such as a deed notice, would be required to prevent future disruption and to prevent disruption of the capped/covered area.

Alternative M5: Channel Excavation/Armored, Extended Shallow Removal, and Thin Cover

Horseshoe Road Site Costs	
Estimated Capital Cost:	$8,300,000
Estimated O&M Cost:	$225,850
Estimated Present Worth Cost:	$8,450,000

ARC Site Costs	
Estimated Capital Cost:	$8,300,000
Estimated O&M Cost:	$225,850
Estimated Present Worth Cost:	$8,450,000

Estimated Construction Time frame:	6 months
Area excavated/backfilled:	4.6 acres
Area capped:	3.8 acres

Under this alternative, the stream channel and all areas with arsenic contamination greater than 1,050 mg/kg would be excavated and backfilled to two feet. Marsh area with arsenic levels above 160 mg/kg, but less than 1,050 mg/kg would be excavated to a depth of one foot and backfilled to 1.5 feet (a total excavation of approximately 10,970 cubic yards). This alternative also armors the channel with stone to prevent erosion and lateral movement. Marsh sediments that are above 32 mg/kg of arsenic or 2 mg/kg of mercury, but below 160 mg/kg arsenic would be covered with a thin cap (approximately six inches). The cap would be constructed in such a way as to allow for the re-establishment of a wetland on top of the cap.

Long-term O&M of the cap and armored channel would be required. Institutional controls, such as a deed notice, would be required to prevent disruption of the capped/covered area.

Alternative M6: Channel Excavation, Extended Deep Removal and Thin Cover

Horseshoe Road Site Costs
Estimated Capital Cost: $9,230,000
Estimated O&M Cost: $225,850
Estimated Present Worth Cost: $9,300,000

ARC Site Costs
Estimated Capital Cost: $9,230,000
Estimated O&M Cost: $225,850
Estimated Present Worth Cost: $9,300,000

Estimated Construction Time frame: 6 months
Area excavated/backfilled: 4.6 acres
Area capped: 1.4 acres

Under this alternative, the stream channel would be dredged to a depth of three feet within a 20 foot-wide corridor, along the SPD/ADC drainage, and areas outside the channel with arsenic contamination greater than 1,050 mg/kg would be dredged to a depth of 2.5 feet. Marsh areas with arsenic levels above 160 mg/kg but less than 1,050 mg/kg would be excavated to a depth of 1.5 foot (a total excavation of approximately 15,015 cubic yards). The channel would then be backfilled to the original contours. Marsh sediments that are above 32 mg/kg of arsenic or 2 mg/kg of mercury, but below 160 mg/kg arsenic would be covered with a thin cap (approximately six inches). The cap would be constructed in such a way as to allow for the re-establishment of a wetland on top of the cap.

Long-term O&M of the cap would be required. Institutional controls, such as a deed notice, would be required to prevent future disruption of the capped/covered area.

Alternative M7: Full Excavation, Restoration

Horseshoe Road Site Costs
Estimated Capital Cost: $10,265,000
Estimated O&M Cost: $125,850
Estimated Present Worth Cost: $10,350,000

ARC Site Costs
Estimated Capital Cost: $10,265,000
Estimated O&M Cost: $125,850
Estimated Present Worth Cost: $10,350,000

Estimated Construction Time frame: 6 months
Area excavated/backfilled: 6.0 acres

Area capped: 0.0 acres

Under this alternative, the stream channel would be dredged to a depth of three feet within a 20 foot-wide corridor along the SPD/ADC drainage, and areas outside the channel with arsenic contamination greater than 160 mg/kg would be dredged to a depth of 2.5 feet. Marsh areas with arsenic levels above 32 mg/kg of arsenic or 2 mg/kg of mercury, but less than 160 mg/kg, would be excavated to a depth of one foot (a total excavation of approximately 21,145 cubic yards). The Marsh would then be backfilled to its original contour.

Institutional controls, such as a deed notice, would be required for this remedy to prevent disruption of the covered area.

COMPARATIVE ANALYSIS OF MARSH ALTERNATIVES

In selecting a remedy, EPA considered the factors set out in CERCLA §121, 42 U.S.C. §9621, by conducting a detailed analysis of the viable remedial response measures pursuant to the NCP, 40 CFR §300.430(e)(9) and OSWER Directive 9355.3-01. The detailed analysis consisted of an assessment of the individual response measure against each of nine evaluation criteria and a comparative analysis focusing upon the relative performance of each response measure against the criteria.

Threshold Criteria - *The first two criteria are known as "threshold criteria" because they are the minimum requirements that each response measure must meet in order to be eligible for selection as a remedy.*

1. Overall Protection of Human Health and the Environment
Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.

All alternatives except the "no action" alternative would provide adequate protection of human health and the environment by eliminating or controlling risk through removal of contaminants or engineering or institutional controls. Alternative M7 (Full Excavation) would be the most protective over the long-term because it removes the most contaminated sediments from the Marsh that could result in exposure or off-site migration of contaminants to the River.

Alternative M4 (Shallow Hot Spot Removal and Thin Cover), M5 (Extended Shallow Removal and Thin Cover), and M6 (Extended Deep Removal and Thin Cover), provide levels of protection through a combination of excavation and capping. The main difference between these three alternatives is the amount of contaminated sediment being excavated and, therefore, eliminated as a source for off-site migration. These alternatives also rely on caps or backfill to cover contaminated sediment that is left in place.

Alternatives M4, M5 and, to a lesser degree M6, rely on thin caps over the top of existing sediment. A thin cap would act through dilution by adding the clean cap material to the surface sediment to dilute the surface concentration. For alternatives that rely on thin caps to cover areas of contaminated sediment, resulting surface concentrations would be slightly higher, and the potential for disruption of the surface cover materials reduces the level of protection.

Alternatives M2 (Channel Excavation, Thin Cover and Monitored Natural Recovery) and M3 **(**Surficial Hot Spot Removal and Monitored Natural Recovery) rely on Monitored Natural Recovery (MNR), which depends on natural processes (burial/dilution by cleaner sediments) to address contaminants. The FS considered a range of factors in evaluating how long it might take MNR to achieve the remediation goals, and concluded that at it would take a minimum of five years (under favorable conditions), but as many as 45 years before the remediation goals would be reached in surface sediments. During this period, exposure scenarios and off-site migration of contaminants would continue much as they are today. Based on the current distribution of sediment at the sites, there is little evidence that MNR is occurring, or that implementation of the OU2 upland remedies would help the performance of MNR.

Because M1, the “No Action” alternative, is not protective of human health and the environment, it was eliminated from consideration under the remaining eight criteria.

All the remaining alternatives would require institutional controls to some degree because some contamination will be left behind. Alternatives M2 and M3 will require long-term monitoring to assure the remediation goals are achieved through MNR. Alternatives M2 through M7 would require O&M to ensure that the cover material remains protective.

2. Compliance with applicable or relevant and appropriate requirements (ARARs)

Section 121(d) of CERCLA and NCP §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA section 121(d)(4).

<u>Applicable requirements</u> are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those State standards that are identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable. <u>Relevant and appropriate requirements</u> are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those State standards that are identified in a timely manner and are more stringent than Federal requirements may be relevant and appropriate.

Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other Federal and State environmental statutes or provides a basis for an invoking waiver.

EPA has developed site-specific remediation goals. Alternative M7 would achieve remediation goals through excavation and backfilling. All the other alternatives would achieve the remediation goals through a combination of excavation, capping and/or MNR.

Alternatives M2 through M7 are expected to satisfy the action- and location-specific ARARs that have been identified, though compliance with ARARs that affect wetlands requires further clarification. Wetlands perform a variety of important functions, such as providing ecological habitats, spawning grounds, and assisting in flood control. The Federal Clean Water Act, Section 404, and Federal Executive Order No. 11990 protect existing wetlands, and portions of these laws are ARARs for the sites. Generally these laws seek to prevent the disruption of existing wetlands when possible; however, because preserving the existing wetland would have precluded most of the remedial technologies available for cleanup, preservation of the existing wetland was not a remedial action objective.

All the active remedial alternatives result in the disturbance of the existing wetland, to varying degrees. The whole marsh drainage area is approximately 8.2 acres, and the area that is contaminated, as defined by arsenic concentrations greater than 32 mg/kg, is 6.0 acres. Alternative M3 disturbs the smallest area within the wetland, (2.2 acres) followed by Alternative M2 (4.6 acres). The remaining four alternatives disturb 6.0 acres of wetland. While each alternative assumes that any disturbed wetlands would be restored, from the point-of-view of wetlands disruption alone, Alternative M3 is preferable because it leaves the majority of the Marsh untouched.

Several of the remedial alternatives result in altering the land surface or surface water flows within the Marsh in subtle but potentially important ways. Alternatives M4, M5 and M6 all rely on thin layer capping, which would raise the land surface over portions of the Marsh to limit access to contaminated sediments below the cap. Raising the land surface can result in increasing surface water flows through the Marsh, or in creating areas that are wetter or drier than pre-remedy conditions; these changes can result in adverse affects in the wetland.

Alternatives M2 and M5 rely on an "armored channel" to prevent the movement of the ADC/SPD drainage channel from its current position. This drainage channel is a slightly deeper preferential pathway for water-flow through the Marsh, and it is the area of highest sediment contamination. Because the meandering channel could expose contaminated sediments that are currently buried, armoring (lining the channel with stone) prevents the channel from meandering in the future. An armored channel has a potential adverse affect on the wetland, because during low flow periods, when the much of the surface water would be found in the channel itself, the armored channel has the potential to "hurry" surface water out of the Marsh, further drying it out.

Capping and armoring the channel cause relatively small changes in how the Marsh functions, and engineering techniques are available that minimize adverse affects from these changes. But even small changes may warrant a "mitigation" under the Clean Water Act, in the form of some kind of further restoration elsewhere to compensate for a localized disruption of wetland function. Of the six active alternatives, only Alternatives M3 and M7 leave the contours of the Marsh unchanged, and are, therefore, neutral with regard to affects on the wetland.

Based upon the available documentation regarding the source of contamination, and sediment testing, EPA has concluded that the marsh sediments are neither listed hazardous waste or exhibit hazardous characteristics, and therefore do not require treatment to meet RCRA Land Disposal Restrictions.

Primary Balancing Criteria *- The next five criteria, criteria 3 through 7, are known as "primary balancing criteria". These criteria are factors with which tradeoffs between response measures are assessed so that the best option will be chosen, given site-specific data and conditions.*

3. Long-term effectiveness and permanence

A similar degree of long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once clean-up levels have been met. This criterion includes the consideration of residual risk that will remain on-site following remediation and the adequacy and reliability of controls.

Long-term effectiveness and permanence would be achieved by all the active alternatives to varying degrees. Alternative M7 (complete removal) would achieve the highest level of long-term effectiveness and permanence because the most contaminated sediments would be permanently removed from the Marsh. The remaining Alternatives (M2 through M6) would leave behind contaminated sediment that would need to be managed in place. With these alternatives there is the possibility that the cover could be breached by a large storm event, dredging, or some other disruption. Alternatives M6 through M4 would rely entirely on clean cover material to prevent exposures to the contaminated sediment that remains, M6 excavating the most contaminated sediment and consequently providing the most cover to the remaining contamination. M5 and M4 leave behind progressively more contaminated sediment, and therefore, achieve a slightly lower level of permanence. Alternatives M3 and M2 each rely to some degree on MNR to address the lower level contamination, which assumes that with time the contaminated surface sediments would eventually be covered with clean sediments through the natural sedimentation processes. Monitoring would be required to determine if these processes are achieving the remediation goals in a reasonable timeframe. EPA would consider M3 and M2 less reliable when considering long-term effectiveness and permanence.

Alternatives M2 and M5 armor the channel to prevent the channel from migrating and eroding out the deeper sediments in adjacent areas. The armored channel minimizes the potential for the channel to meander and expose currently buried contaminants, and so would add to the long-term permanence of these alternatives.

4. Reduction of toxicity, mobility, or volume

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

None of the alternatives treat contaminated sediments. Alternative M7 would provide the greatest reduction of contaminant mass at the sites, but does not rely on treatment.

5. Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community and the environment during construction and operation of the remedy until cleanup levels are achieved.

All the active alternatives involve at least some excavation and thus present a potential for minor short-term challenges. Alternative M2 requires the least excavation and presents the lowest short-term difficulties to the community or site workers, with M3 only slightly more difficult. Alternatives M4, M5, M6 and M7 would pose greater challenges in the short term compared to Alternatives M2 and M3 because larger and deeper excavations would pose an increased risk of short term exposure as well as increased materials handling. However, proper health and safety measures can mitigate these risks.

The risk of release during remedy implementation is principally limited to wind-blown transport or surface water runoff. This is expected to be minimal based on the high moisture content of the sediments. Any potential environmental impacts associated with dust and runoff would be minimized with proper installation and implementation of dust and erosion control measures. In the event of a catastrophic storm that occurred during the implementation phase of one of the active alternatives, the risk of additional sediment releases would increase over the current conditions, because vegetation that currently minimizes sediment movement would be removed; however, there is little difference in the implementation time from the shortest (three months) to the longest (six months), so no alternative is substantially more favorable from this standpoint.

Implementation times of the remedial alternatives are as follows:

M2 and M3 would require three months to construct and a minimum of five years, but as many as 45 years, to reach the remediation goals for surface sediments; M4 would require three months, and M5/M6/M7, six months to implement, and the remediation goals would be achieved at that time.

6. Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

Although all of the alternatives are technically and administratively implementable, because they all utilize standard construction equipment and services, and require similar permit equivalencies, it is unclear whether natural recovery would be effective in achieving the remediation goals in a reasonable timeframe, if at all. Natural recovery is a type of remedy that EPA can consider if natural processes appear likely to achieve goals for a site, or part of a site, in a timeframe that is similar to other active remedies. Using favorable assumptions about sediment rates, the FS report predicts the MNR portion of Alternatives M2 and M3 could achieve remediation goals within five years. All of the other remedial alternatives achieve the remediation goals for the Marsh within the first year after implementation and while these implementation times are not similar, a five-year implementation time is still considered reasonable. The FS also considered less favorable sedimentation rates and calculated timeframes as long as 45 years to reach remediation goals, a timeframe that is clearly unacceptable. This broad range (five years to 45 years) suggests a level of uncertainty about whether MNR can be relied upon to achieve the remediation goals.

EPA considers Alternatives M2 and M3 to be questionable for overall implementability.

7. Cost

Includes estimated capital and O&M costs, and net present worth value of capital and O&M costs.

As discussed above, cost estimates were developed jointly for the two sites without regard to the relative cost contribution of each site and, therefore, costs are divided equally between the sites. EPA has not attempted to assess the actual contribution of each site to marsh contamination. Actual allocations will be done at a future date when more information is available.

Summing the per-site costs for each alternative provides the total cost for each alternative.

For the Horseshoe Road site, the estimated present worth costs of Alternatives M2, M3, M4, M5, M6 and M7 are $3.7 million, $4.0 million, $7.5 million, $8.45 million, $9.3 million and $10.35 million, respectively.

For the Atlantic Resources site, the estimated present worth costs of Alternatives M2, M3, M4, M5, M6 and M7 are $3.7 million, $4.0 million, $7.5 million, $8.45 million, $9.3 million and $10.35 million respectively.

Excavation and off-site disposal of contaminated sediments is the primary cost variable across the remedial alternatives, M2 (1,291 cubic yards) excavating the smallest quantity and M7 (21,145 cubic yards) the largest. The difference in cost between M2 or M3 and the remaining alternatives is substantial, whereas the costs of Alternative M4 through M7 are generally comparable.

O&M costs for Alternatives M2, M3 and M4 are the highest, because they rely primarily on capping or MNR, and require additional on-site management to assure protectiveness or, in the case of MNR, monitoring to assure that the remedy is reaching the remedial goals for the Marsh. Alternative M7 has the lowest O&M cost, because it leaves only inaccessible deeper sediments in place at the conclusion of the remedial action, and monitoring for that alternative focuses primarily on assuring that the wetland is restored.

The potential for remedy failure (e.g., a substantial disruption of a cap following a catastrophic storm event) to a degree that would require a second cleanup effort to restore damage to a remedy is not accounted for in the estimated costs of any of the alternatives.

When comparing the cost of each of these alternatives, it is apparent that what is achieved by the increase in cost from M2 to M7 is a decreased potential for remedy failure. For the Marsh, one must consider that a failure here may compromise the down-gradient river remedy. Alternatives M2 and M3 are unproven, and may require implementation of another alternative should they fail to perform as expected. Alternatives M4 through M7 progressively depend on more excavation and less thin capping. The result is a more robust remedy. M7 leaves very little contaminated sediment on site and covers it with a very thick layer of backfill, and even a major storm event would have very little chance of exposing buried contamination. At the other end of the spectrum is M4, which relies completely on a thin-layer cap to address arsenic contamination at concentrations up to 1,050 mg/kg. In the case of Alternative M4, the potential for failure during a storm or disruption from human activity is much greater.

Modifying Criteria *- The final two evaluation criteria, criteria 8 and 9, are called "modifying criteria" because new information or comments from the state or the community on the Proposed Plan may modify the preferred response measure or cause another response measure to be considered.*

8. State acceptance

Indicates whether based on its review of the RI/FS reports and the Proposed Plan, the state supports, opposes, and/or has identified any reservations with the selected response measure.

The State of New Jersey concurs with EPA's preferred alternative in this Record of Decision; however, it should be noted that the selected remedy does not address primary and compensatory restoration of natural resources.

9. Community acceptance

Summarizes the public's general response to the response measures described in the Proposed Plan and the RI/FS reports. This assessment includes determining which of the response measures the community supports, opposes, and/or has reservations about.

EPA solicited input from the community on the remedial response measures proposed for the sites. Oral comments were recorded from attendees of the public meeting. Written comments were received from the EWA, and a group of Potentially Responsible Parties (PRPs). The primary areas of concern for both EWA and the PRPs were the remediation goals for contaminated sediments and whether the depths of the sediment excavations considered in the Proposed Plan were appropriate to the sites. EWA expressed concerns that EPA had not been sufficiently protective in selecting remediation goals and that the depths of removal were insufficient, and the PRPs indicated that EPA had been overly conservative in assessing the ecological risks and potential for off-site transport of contaminated sediments, such that the preferred remedial alternative was unnecessarily conservative and expensive. Appendix V, The Responsiveness Summary, addresses all the comments received both oral and written.

DESCRIPTION OF RIVER ALTERNATIVES

Using the Remediation Goals of 100 mg/kg for arsenic and 2.0

mg/kg for mercury in river sediments, the FS targeted an area (marked on Appendix I, Figure 3) for remediation. Given the difficulties of collecting reproducible data in river sediments and the potential for multiple point sources for the COCs in the River, EPA expects to limit its River response to the mudflat areas identified in Appendix I, Figure 3, a depositional zone that is clearly affected by the sites.

As with the marsh sediments, the FS used zones defined by the Remediation Goals but divides the river sediments into additional zones, to assess a wider variety of response actions. In addition to areas defined by the Remediation Goals, river sediments were further divided into an area that exceeds 194 mg/kg for arsenic and 2.6 mg/kg for mercury. These values are based on the amphipod bioassay performed as part of the BERA. This area is considered more critical, and contains most of the contaminant mass. The second zone is characterized by sediments that are less than 194 mg/kg of arsenic but exceed the Remediation Goals. As with the Marsh alternatives, the river alternatives presented in the FS address these zones to varying degrees as described in the summary of remedial alternatives below.

Common Elements

Many of the alternatives include common components. The FS assumes that the OU2 remedies and Marsh remedies will eliminate these areas as ongoing sources of contamination to river sediments. It is expected that these other remedies would be performed before, or at least concurrently with the active remedial alternatives evaluated below.

Because the COCs (arsenic, mercury and PCBs) are commonly found in sediments of the Raritan River Estuary, and because only a small portion of the sediment contamination in the Estuary can be reasonably attributed to the sites, the remedial actions contemplated for the River are limited to addressing a hotspot that is clearly attributable to the sites. EPA expects that the area targeted for remediation will be recontaminated to at least the background levels found throughout the Estuary. Post-remedy sediment monitoring in the River would be needed to assess whether actions taken to address this hotspot have been effective, and whether the Marsh remedy was effective at eliminating the Marsh as a continuing source to the River.

Five-year reviews will be conducted. In addition, EPA will identify institutional controls to prevent disruption of the remedy. Institutional controls may include a Restricted Navigation Area or other similar control that would limit activities in the River that could disturb subaqueous capped areas.

Please refer to Appendix I, Figure 5 for a simplified depiction of each river alternative.

Alternative R1: No Action

Estimated Capital Cost:	$0
Estimated (O&M) Cost:	$0
Estimated Present Worth Cost:	$0

Estimated Construction Time frame:	None
Area dredged:	0.0 acres
Area Backfilled :	0.0 acres
Area capped:	0.0 acres

Regulations governing the Superfund program expect that the “no action” alternative will be evaluated to establish a baseline for comparison. Under this alternative, EPA would take no further action in the River to prevent exposure to sediment contamination, or to prevent the further migration of site contamination from the hotspot area. Institutional controls, such as a deed notice, would not be implemented to limit access to this area. Engineering controls would not be implemented to prevent site access or exposure to site contaminants.

Alternative R2: Monitored Natural Recovery

Horseshoe Road Site Costs	
Estimated Capital Cost:	$120,000
Estimated O&M Cost:	$410,000
Estimated Present Worth Cost:	$335,000

ARC Site Costs	
Estimated Capital Cost:	$120,000
Estimated O&M Cost:	$410,000
Estimated Present Worth Cost:	$335,000

Estimated Construction Time frame:	0 months
Area dredged:	0.0 acres
Area requiring cover:	0.0 acres

This alternative relies on natural processes in the River, such as dilution and deposition of cleaner sediments at the surface, to reduce exposures to human and ecological receptors. This alternative is similar to Alternative R1 with the exception that there would be monitoring performed to determine the rate of recovery.

Institutional controls would be required to prevent disruption of the recovered area.

Alternative R3: Shallow Dredge and Thin Cover

Horseshoe Road Costs	
Estimated Capital Cost:	$1,310,000
Estimated O&M Cost:	$410,000
Estimated Present Worth Cost:	$1,400,000

ARC Costs	
Estimated Capital Cost:	$1,310,000
Estimated O&M Cost:	$410,000
Estimated Present Worth Cost:	$1,400,000

Estimated Construction Time frame:	1-2 months
Area dredged:	0.8 acre
Area requiring cover:	2.5 acres

Under this alternative, approximately 1,290 cubic yards of sediment in the River that exceed 194 mg/kg arsenic and 2.6 mg/kg mercury would be dredged to a depth of approximately one foot, and clean material would be used as backfill to restore the dredged area to the original contour. The remaining sediments within the area targeted for remediation would be covered with a thin sand layer (approximately six inches) that would both dilute contaminant concentrations at the surface and act as a cap on the more contaminated sediment below.

This alternative would require monitoring to ensure that the cover material remains in place and is functioning as expected. Institutional controls would be required to prevent disruption of the capped sediments.

Alternative R4: Extended Shallow Dredge and Cover

Horseshoe Road Site Costs	
Estimated Capital Cost:	$2,745,000
Estimated O&M Cost:	$410,000
Estimated Present Worth Cost:	$2,800,000

ARC Site Costs	
Estimated Capital Cost:	$2,745,000
Estimated O&M Cost:	$410,000
Estimated Present Worth Cost:	$2,800,000

Estimated Construction Time frame:	1-2 Months
Area dredged:	2.5 acres

Area requiring cover:	2.5 acres

Under this alternative, approximately 4,030 cubic yards of sediment within the area targeted for remediation (arsenic greater than 100 mg/kg or mercury greater than 2mg/kg) would be dredged to a depth of approximately one foot, and clean material would be used to restore the dredged area to the original contour.

This alternative would require monitoring to ensure that the cover material remains in place and is functioning as expected. Institutional controls would be required to prevent disruption of the capped sediments.

Alternative R5: Deep Dredge and Natural Resedimentation

Horseshoe Road Site Costs	
Estimated Capital Cost:	$5,335,000
Estimated O&M Cost:	$410,000
Estimated Present Worth Cost:	$5,450,000

ARC Site Costs	
Estimated Capital Cost:	$5,335,000
Estimated O&M Cost:	$410,000
Estimated Present Worth Cost:	$5,450,000

Estimated Construction Time frame:	3-4 months
Area dredged:	2.5 acres
Area requiring cover:	0.0 acres

Under this alternative, approximately 14,120 cubic yards of sediment within the area targeted for remediation (arsenic greater than 100 mg/kg or mercury greater than 2 mg/kg) would be dredged to a depth of approximately 3.5 feet, but no cover material would be placed in the dredged area. The depth of dredging would be determined by the extent of contaminated sediments in excess of the Remediation Goals, but would not be deeper than 3.5 feet. Based upon the available sampling data, this dredging effort would be expected to remove most, but possibly not all the sediments in the target area that exceed the remediation goals; additional sediment sampling would be required to determine if this is the case. Natural sedimentation would be expected to fill in the dredged area over time, providing a layer of cover over any residual sediment contamination that might exist beneath the area dredged.

This alternative may require monitoring if contaminated sediment is left behind to ensure that natural sedimentation covers any remaining contaminated sediment in order to achieve the

Remediation Goals. Under this alternative, if contamination will be left behind at depth, institutional controls would be required to prevent disruption of the sediments buried by natural sedimentation.

Alternative R6: Deep Dredge and Cover

Horseshoe Road Site Costs	
Estimated Capital Cost:	$6,710,000
Estimated O&M Cost:	$45,000
Estimated Present Worth Cost:	$6,750,000
ARC Site Costs	
Estimated Capital Cost:	$6,710,000
Estimated O&M Cost:	$45,000
Estimated Present Worth Cost:	$6,750,000
Estimated Construction Time frame:	3-4 months
Area dredged:	2.5 acres
Area requiring cover:	2.5 acres

Under this alternative, approximately 14,120 cubic yards of sediment within the area targeted for remediation (arsenic greater than 100 mg/kg or mercury greater than 2 mg/kg) would be dredged to a depth of approximately 3.5 feet, and 3.5 feet of clean material would be used to restore the dredged area to its original contour. The depth of dredging would be determined by the extent of contaminated sediments in excess of the Remediation Goals, but would not be deeper than 3.5 feet.

This alternative would require monitoring so that the cover material is not disturbed, though variations in the thickness of the cover as a result of natural events (severe weather, ice scour) is expected, and would not affect the protectiveness of the cover. Under this alternative, EPA will need to evaluate whether contamination will be left behind, in order to determine if institutional controls would be required to prevent disruption of the covered sediments.

COMPARATIVE ANALYSIS OF RIVER ALTERNATIVES

1. Overall Protection of Human Health and the Environment

Alternatives R3, R4, R5 and R6 provide varying levels of protection of human health and the environment through combinations of dredging, covering, institutional controls, and monitoring. The “no action” alternative and Alternative R2 (Monitored Natural Recovery) take no action to reduce the potential for direct contact exposure or the potential for the hotspot area to be a continuing source of contamination to the River, and neither of these alternatives appear to satisfy the remedial action objectives for river sediments. While natural sedimentation and dilution may eventually reduce the surface sediment concentrations somewhat, the timeframes for this recovery may be quite long. In the FS, MNR was modeled to take as little as three years and as long as 65 years; however, there is only marginal evidence of natural recovery to date. The site sources that would have provided a continuing source of contaminated sediments during facility operations appear to have substantially diminished, and the facilities have not operated for over 20 years; yet, this diminished sediment loading has not appeared in the surface sediment concentrations as "recovery" (a clear pattern of reduced concentrations). In addition, because most of the area targeted for remediation is in a depositional zone of the River and is currently a mudflat at low tide, it is very difficult for new, cleaner sediment to deposit on the surface, unless the more highly contaminated sediments are first removed, and if the highly contaminated sediments are removed through the natural redistribution of sediments throughout the River, it would not satisfy the remedial action objectives.

Alternatives R6 (Deep Dredge and Cover) and R5 (Deep Dredge and MNR) provide the largest mass reduction, one method of evaluating environmental protection. Alternatives R3 (Shallow Dredge and Thin Cover) and R4 (Extended Shallow Dredge and Cover) also remove a portion of the most highly contaminated and accessible sediments (those at the surface) but rely more heavily on cover material to manage deeper sediments. Alternatives R3 through R6 rely on covering contaminated sediments left in place, to varying degrees. Alternative R3 may offer a slightly lesser degree of protectiveness than the others, because a thin-layer cover is expected to mix and dilute with contaminated bottom sediments, and the resulting surface sediment concentrations may be slightly higher than for the other active alternatives.

Long-term maintenance and monitoring would be required to ensure that cover material remains in place, and efforts made to assure that the cover material is not disturbed, through the designation of a Restricted Navigation Area, (RNA) or similar control.

Because Alternative R1, the “No Action” alternative, and Alternative R2 (MNR) do not satisfy the remedial action objectives for the river sediments, they were eliminated from consideration under the remaining eight criteria.

2. **Compliance with ARARs**

Actions taken at any Superfund site must meet all applicable or relevant and appropriate requirements of federal and state law or provide grounds for invoking a waiver of those requirements. There are no chemical-specific ARARs for the contaminated river sediments. The Remediation Goals are risk-based. Alternative R6 would address the Remediation Goals through dredging and backfilling, and the other alternatives would achieve the Remediation Goals by dredging and capping. The active remedial alternatives would comply with action-specific ARARs and location-specific ARARs that regulate dredging, filling, and discharge into wetlands and floodplains. A complete list of ARARs/TBCs may be found in the FFS and in Appendix II, Table 10 of this ROD.

Based upon the available documentation regarding the source of contamination and sediment testing, EPA has concluded that the river sediments are neither listed hazardous waste or exhibit hazardous characteristics, and therefore do not require treatment to meet RCRA Land Disposal Restrictions prior to disposal in a RCRA-compliant unit.

3. **Long-term Effectiveness and Permanence**

Long-term effectiveness and permanence would be achieved by Alternatives R3, R4, R5, and R6, to varying degrees. Alternatives R6 (Deep Dredge and Cover) would achieve the highest level of long-term effectiveness and permanence because the largest mass of contaminated sediment would be permanently removed from the River and the thickest layer of cover material would be put in place. Alternative R5 could be considered slightly less effective because it relies on natural processes to cover any residual contamination that may remain; however, after sediment dredging to 3.5 feet, the dredged area would be expected to create a local depositional environment that would accumulate sediment at a higher rate than the surrounding areas, providing cover material relatively rapidly.

Alternatives R3 (Shallow Dredge and Thin Cover) and R4 (Extended Shallow Dredge and Cover) provide long-term effectiveness and permanence by dredging the most highly contaminated and accessible sediments at the surface, and placing a sediment cap over residual contaminated sediment; these sediment caps need to be monitored to assure that they will remain in place. Alternative R4 would be considered more reliable over the long-term compared to Alternative R3, because the thin sand cover of Alternative R3 is placed on top of existing sediments and is more prone to the natural redistribution of river-bottom sediments (some portion of the cap material would be washed away), whereas cover material for Alternative R4 is placed after dredging, and the river bottom is essentially unchanged. In addition, the one foot of cover material in Alternative R4 would have little mixing and dilution of surface sediments, whereas the six-inch sand cover in Alternative R3 relies, at least partially, on mixing and dilution of the surface sediment concentrations, and the resulting surface sediment concentrations would be higher.

Alternatives R3 and R4 are more at risk of failure from sediment disturbance than are Alternatives R5 or R6, which incorporate a thicker cover layer. The most likely causes of sediment disturbance would be human activities (such as boating or dredging) or ice scour during the winter months. The capped area in the River would be designated as a Restricted Navigation Area (RNA) where anchoring would not be allowed, and access would be restricted. The RNA would also be marked on navigational charts. Alternatives R3 and R4 rely heavily on an RNA, and on the limited accessibility of this area to larger water craft to prevent damage to a capped area, while alternatives R5 and R6 would rely more on deeper contamination removal and cover to prevent failure. While preventative measures can be put in place to prevent human disturbance of this area, the only measure to address ice scour would be deeper removal and cover as provided in alternatives R5 and R6. In the case of R5 however, the time required for the natural sedimentary processes to fill in the excavated area is uncertain and, therefore, it is unclear when the remedy would become fully protective.

For any of the remedial alternatives considered, background sediment contamination present throughout the Raritan River Estuary will result in the some recontamination of surface sediments over the long term.

4. **Reduction of Toxicity, Mobility, or Volume of Contaminants Through Treatment**

None of the alternatives involve treatment of the contaminated sediments. Alternatives R6 and R5 remove the most contaminated mass from the River, and therefore do reduce the most volume. However, treatment is not involved and these alternatives do not do more than the other alternatives to satisfy EPA's preference for treatment of wastes.

5. **Short-term Effectiveness**

All of the alternatives would be effective over the short term. Alternatives R3 through R6 involve at least some dredging and thus present minor short-term challenges. The risk of release during remedy implementation is principally limited to resuspension of sediments in the River, and to wind-blown transport or surface water runoff from stock piles. All potential environmental impacts associated with resuspension, dust and runoff can be minimized with proper engineering controls.

Risk to workers posed by normal dredging and materials-handling should be minimal and proper health and safety measures should mitigate this risk.

For the remaining alternatives with the exception of Alternative R5 (Deep Dredge and Natural Resedimentation), once the construction phase is complete, the remedy will be fully effective. The implementation time for Alternatives R3 and R4 is about two months, while Alternative R6 would require four months. Alternative R5 would require about four months to construct and at least 30 months before sedimentation would cover the sediments to a depth that is protective, resulting in an implementation time of about three years.

6. **Implementability**

Alternatives R3 through R6 are technically and administratively implementable, because they all utilize standard construction equipment and services, and require similar permit equivalencies.

7. **Cost**

As discussed above, cost estimates were developed jointly for the two sites without regard to the relative cost contribution of each site and, therefore, costs are divided equally between the sites. EPA has not attempted to assess the actual contribution of each site to river contamination. Actual allocations will be done at a future date when more information is available.

For the Horseshoe Road site, the estimated present worth costs of Alternatives R2, R3, R4, R5, and R6 are $0.34 million, $1.4 million, $2.8 million, $5.45 million, and $6.75 million, respectively.

For the ARC site, the estimated present worth costs of Alternatives R2, R3, R4, R5, and R6 are $0.34 million, $1.4 million, $2.8 million, $5.45 million, and $6.75 million, respectively.

Dredging and off-site disposal of contaminated sediments is the primary cost variable across the remedial alternatives, with

Alternative R3 dredging the least (1,290 cubic yards) and Alternatives R5 and R6 dredging the most (14,117 cubic yards). The long-term monitoring costs for alternatives R2 through R5 are higher, because they rely primarily on covering or MNR, and require additional on-site management to assure protectiveness or, in the case of MNR, monitoring to assure that the remedy is reaching the remedial goals for the River. Alternative R6 has the lowest long term monitoring cost, because it leaves only inaccessible deeper sediments in place at the conclusion of the remedial action. The potential for remedy failure (e.g., a substantial disruption of a cap following a catastrophic storm event) to a degree that would require a second cleanup effort to restore damage to a remedy is not accounted for in the estimated costs.

8. State acceptance

The State of New Jersey concurs with EPA's preferred alternatives in this Record of Decision; however, it should be noted that the Selected Remedy does not address primary and compensatory restoration of natural resources, which is normally addressed by the state and federal natural resource trustees and not subject to CERCLA.

9. Community acceptance

EPA solicited input from the community on the remedial response measures proposed for the sites. Oral comments were recorded from attendees of the public meeting. Written comments were received from the EWA, and a group of PRPs. As with the marsh sediments, the primary areas of concern for both EWA and the PRPs were the remediation goals for contaminated sediments and whether the depths of the sediment dredging considered in the Proposed Plan were appropriate to the sites. As with the marsh sediments, EWA was concerned that EPA had not been sufficiently protective for the River, and the PRPs indicated that EPA had been overly conservative. Appendix V, The Responsiveness Summary, addresses all the comments received both oral and written.

PRINCIPAL THREAT WASTE

Contaminants in surface soils on both the Horseshoe Road and ARC sites have been identified as “principal threat wastes” because these contaminants have demonstrated a potential for migrating to the groundwater; no principal threat wastes have been identified in the sediments in the Marsh or the River.

SELECTED REMEDY

Based upon consideration of the results of the site investigation, the requirements of CERCLA, the detailed analysis of the response measures, and public comments, EPA has determined that Marsh Alternative M7, Full Excavation, Restoration, and River Alternative R6, Deep Dredge and Cover, satisfy the requirements of CERCLA §121 and the NCP's nine evaluation criteria for remedial alternatives, 40 CFR §300.430(e)(9). Alternatives M7 and R6 are comprised of the following components.

- Excavation, transportation and disposal of approximately 21,000 cubic yards of contaminated sediments from the Horseshoe/ARC Marsh;

- Dredging an estimated 14,000 cubic yards of contaminated sediments from the Raritan River;

- Dewatering and off-site disposal of excavated/dredged sediments in an appropriate land disposal facility;

- Backfilling and grading of all excavated marsh areas with clean cover material to allow for reestablishment of wetland habitat;

- Filling of the dredged river area with clean cover material that will support the reestablishment of a benthic community in surface sediments;

- Institutional controls in the Marsh, such as a deed notice or covenant, to prevent exposure to residual soils that may exceed levels that would allow for unrestricted use that may remain at the completion of the remedial action;

- Institutional controls for the river sediments such as a restricted navigation area, to prevent disruption of cover in the event contaminated sediments are left at depth;

- On-site restoration of approximately six acres of wetlands disturbed during implementation of the remedy.

The selected sediment alternative for the Marsh was selected over other alternatives because it is expected to achieve substantial and long-term risk reduction through off-site disposal, and is expected to allow the property to be used for the reasonably anticipated future land use, which is open space/wetland. The selected Marsh remedy reduces the risk within a reasonable time frame, at a cost comparable to other alternatives and is reliable over the long term. Although M7 and M6 are very similar in most respects, M7 was chosen because it removes a higher mass of contaminants at only slightly higher cost than M6. Since the selected remedy would achieve the remediation goals that are protective for the current expected human exposure scenarios (recreational land use), but are not expected to achieve levels that would allow for unrestricted use, institutional controls, such as a deed notice or covenant, may be needed to prevent a change in land use.

As described under "Summary of Site Characteristics," above, EPA concluded that groundwater transport of contaminants from upland soils was highly unlikely, and that deeper sediments are "stable." EPA's National Remedy Review Board recommended that the Region further evaluate whether the groundwater interaction between shallow and deep sediments within the Marsh is adequately understood, and whether any contaminated sediments that are left in place at depth might recontaminate newly placed fill to levels that would not be protective, through remobilization and transport of deeper sediment contamination. Studies during the remedial design for the selected Marsh remedy will further clarify this issue.

The River portion of the selected remedy was selected over the other alternatives because it is expected to achieve substantial and long-term risk reduction through off-site disposal of dredged sediments, reducing contaminant levels in the River, and reducing the mudflat area as a source of contamination to the River. The selected remedy reduces the risk within a reasonable timeframe, at a reasonable value for the money spent, and provides for long-term reliability of the remedy.

The depth of River dredging required by the Selected Remedy will be determined by the extent of contaminated sediments in excess of the Remediation Goals, but will not be deeper than 3.5 feet. Based upon available sampling data, this dredging action will remove most, but possibly not all the sediments that exceed the Remediation Goals; however, additional sediment sampling will be required to determine if this is the case. If contaminated sediments are left behind, the 3.5 feet of cover material will provide a sufficient barrier to natural events, such as severe storms or ice scour, and natural variations in the thickness of this cover are not expected to compromise the protectiveness of the cover. To the degree that institutional controls are required, it is to prevent human disruption of the cover. Although Alternative R4 and, to a lesser amount Alternative R3 would provide protectiveness at the surface to a degree that would be similar to R6, EPA believes that the additional long-term effectiveness and permanence in a river setting, where conditions cannot be as easily controlled as on land, justifies the additional cost of removing a larger quantity of contaminated sediments.

EPA expects that at least some sediments deeper than 42 inches are contaminated at concentrations greater than the remediation goals, and these sediments will be left in place; therefore, EPA also believes that the placement of cover over the dredged area, as called for in Alternative R6 but not in Alternative R5, provides a more reliable and effective remediation approach that reaches the remedial action objectives sooner, with no uncertainty about the when, or to what the degree the Remediation Goals are met at the surface. EPA’s National Remedy Review Board, in reviewing Region 2's remedial plans for OU3, recommended that the Region consider a middle path between Alternatives R5 and R6. The Board recommended that some minimal backfilling of the dredged area might take place in the River to assure the isolation of deeper sediments, but natural sedimentary processes in the River might be relied upon to fill in the remainder. EPA expects that this approach would eliminate the short term exposure concerns that might be posed by Alternative R5, thus providing a cost savings while achieving an equivalent level of protectiveness to the original Alternative R6. EPA will evaluate the amount of backfill needed during the remedial design for OU3.

With regard to the long-term surface sediment conditions, EPA expects that areas of the River remediated during OU3 will be recontaminated to levels similar to the reference values identified in Appendix II, Table 2.

STATUTORY DETERMINATIONS

As was previously noted, CERCLA § 121(b)(1) mandates that a remedial action must be protective of human health and the environment, cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Section 121(b)(1) also establishes a preference for remedial actions which employ treatment to permanently and significantly reduce the volume, toxicity or mobility of the hazardous substances, pollutants, or contaminants at a site. CERCLA § 121(d) further specifies that a remedial action must attain a degree of cleanup that satisfies ARARs under federal and state laws, unless a waiver can be justified pursuant to CERCLA § 121(d)(4).

Protection of Human Health and the Environment

The Selected Remedies, Marsh Alternative M7 coupled with River Alternative R6, will be protective of human health and the environment through the removal of contaminated sediments from the sites that are both contact hazards and contribute to environmental impacts both in the Marsh and River. In addition, the implementation of institutional controls will prevent future exposure to contaminated sediment. Monitoring will further ensure that contaminated sediments that remain on site will not impact human health and the environment.

Compliance with ARARs

The Marsh sediment and River sediment remedial actions will comply with all federal and state requirements that are applicable or relevant and appropriate (ARAR) to their implementation. A comprehensive ARAR discussion is included in the FFS and a complete listing of ARARs is included in Table 10 of this ROD.

Chemical-Specific ARARs There are no chemical-specific ARARs for the contaminated Marsh or River sediments.

Action-Specific ARARs Based upon the available documentation regarding the source of contamination and sediment testing, EPA has concluded that the Marsh and River sediments are neither listed hazardous waste or exhibit hazardous characteristics, and therefore do not require treatment to meet RCRA Land Disposal Restrictions prior to disposal in a RCRA-compliant unit.

EPA has not identified PCB contamination within OU3 at levels high enough to trigger the PCB management requirements of the Toxic Substances Control Act (TSCA). In the event that PCB contamination is found during design sampling at levels high enough to trigger such requirements, EPA will delineate the wastes in place and manage them in accordance with 40 CFR Part 761.

Action-specific ARARs will be achieved by conducting remedial action activities in accordance with OSHA, RCRA, New Jersey hazardous waste regulations, New Jersey Soil Erosion and Sediment Control Act regulations,

Federal Surface Water Quality Criteria and State Water Surface Water Quality Standards will be included in the design specifications to ensure compliance with the Clean Water Act (CWA) and State Water Pollution Control Act during the implementation of the River remedial action. In assessing the affects of sediment dredging on water quality, EPA has concluded that there will be no long-term exceedences of the Federal criteria or State standards resulting from the remedy and, given the small size of the dredging action relative to size of the River, the short-term affects will be inconsequential. In performing the remedial action, EPA will comply with the substantive requirements of New Jersey regulations that govern the management and regulation of dredging activities, which require best practices to minimize the release of sediment contamination into the water column.

Location-Specific ARARs Location-specific ARARs will be achieved by conducting remedial action activities in accordance with the National Environmental Policy Act, specifically with regard to carrying out Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands), and New Jersey statutes governing floodplains and protection of wetlands.

River remedial actions involving the management of contaminated sediments will be conducted in accordance with the Rivers and Harbors Act, Section 10 regulations, and NJDEP sediment dredging regulations.

Endangered Species Act (16 U.S.C. 1531) requirements for the protection of federally listed threatened and endangered species and their habitat will be met.

Since the Raritan Estuary is located within a coastal management zone, and since the Marsh and River remedial actions may affect a coastal use or resource, the federal Coastal Zone Management Act requires that the remedy be undertaken in a manner consistent, to the maximum extent practicable, with New Jersey's Coastal Management Program. It is expected that the requirement will be satisfied by the Selected Remedy for the sites.

Cost Effectiveness

In the lead agency's judgment, the Selected Remedy is cost-effective and represents a reasonable value for the money to be spent. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness." (NCP §300.430(f)(1)(ii)(D)). EPA evaluated the "overall effectiveness" of those alternatives that satisfied the threshold criteria (*i.e.*, were both protective of human health and the environment and ARAR-compliant). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness). Overall effectiveness was then compared to costs to determine cost-effectiveness. EPA considered whether the overall effectiveness of Alternatives M7 and R6 were substantially greater than the remedial alternatives that rely more heavily on containment, with estimated present worth costs for each site in the range of $7.5 million to $8.5 million for

Marsh alternatives and $1.4 million to $2.8 million for River alternatives. The relationship of the overall effectiveness of these remedial alternatives were determined to be proportional to their costs and hence, these alternatives represent a reasonable value for the money to be spent.

For the Horseshoe Road site: The estimated present worth cost of Alternative M7 (Full Excavation, Restoration) is $10.4 million and Alternative R6 (Deep Dredge and Cover) is $6.8 million.

For the ARC site: The estimated present worth cost of Alternative M7 (Full Excavation, Restoration) is $10.4 million and Alternative R6 (Deep Dredge and Cover) is $6.8 million.

For a detailed cost summary of Alternatives M7 and R6, see Appendix II, Table 11, of this document.

Utilization of Permanent Solutions and Alternative Treatment Technologies

EPA has determined that the Selected Remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the sites. Of those alternatives that are protective of human health and the environment and comply with ARARs to the extent practicable, EPA has determined that the Selected Remedy provides the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element, the bias against off-site treatment and disposal, and State and community acceptance.

The Selected Remedy will provide adequate long-term control of risks to human health and the environment through excavation and off-site disposal of contaminated marsh sediments, dredging, dewatering and off-site disposal of river sediments, and institutional controls. The Selected Remedy does not present short-term risks different from the other alternatives. There are no special implementability issues since the remedy employs standard technologies.

Preference for Treatment as a Principal Element

The Selected Remedy will not meet the statutory preference for the use of remedies that involve treatment as a principal element. The FS did not identify viable technologies for addressing the media of concern that included treatment.

Five-Year Review Requirements

This remedy is expected to result in hazardous substances, pollutants, or contaminants remaining on the Horseshoe Road and ARC sites above levels that may allow for unlimited use and unrestricted exposure. Pursuant to Section 121(c) of CERCLA, a statutory review will be conducted within five years of the initiation of the remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan for the Horseshoe Road and ARC sites was released for public comment on July 21, 2008. The comment period closed on August 20, 2008.

The Proposed Plan identified Alternative M7, Full Excavation, Restoration, and Alternative R6 Deep Dredge and Cover as EPA's selected alternatives. EPA reviewed all written and verbal comments submitted during the public comment period. The comments received were documented in the Responsiveness Summary.

In response to a request from a reviewer of the Proposed Plan, the Region presented EPA's proposed remedy to EPA's National Remedy Review Board on November 19, 2008. Prior to the November meeting, the Region extended an invitation to all stakeholders who had provided written comments on the Proposed Plan to also submit a written position to the Board, and most of the commenters did so. These stakeholder statements are included in the Administrative Record for the sites. The comments that were received from the Board, and the Region's responses, are included in the Administrative Record. The Board's comments resulted in a number of modifications and clarifications to this decision, and in response the Region has made the following two modifications to the remedy that was originally identified in the Proposed Plan:

- For Alternative M7, EPA will further evaluate, during remedial design, the groundwater interaction between shallow and deep sediments within the Marsh, to ensure that any contaminated sediments that are left in place at depth would not recontaminate newly placed sediments to levels that would not be protective; and
- For Alternative R6, EPA will evaluate during remedial design whether after dredging it is equally protective and cost-effective to place a thinner cap in the dredged area and allow natural sedimentary processes in the River to fill in the remainder.

APPENDIX I
FIGURES

APPENDIX II
TABLES

TABLE 1

Horseshoe/ARC Marsh Surface Sediment Data (2006 Sampling Only)

COC (mg/kg)	Reference[1] Samples (range)	Marsh Sediments (range)
Arsenic	6.7-49.9 mg/kg	16.6-17,800 mg/kg
Mercury	0.18-1.4 mg/kg	0.36-385 mg/kg
PCBs	0.01-0.77 mg/kg	0.08-32 mg/kg

[1]Reference Samples were taken during the BERA investigation in areas considered background to the site.

TABLE 2
Horseshoe/ARC Raritan River Sediment Data

COC (mg/kg)	Reference[1] Samples (range)	Near-site River Sediments (range)
Arsenic	6 - 47 mg/kg	9.1 - 2,200 mg/kg
Mercury	0.08 -1.3 mg/kg	0.062 - 7 mg/kg
PCBs	0.06 - 0.89 mg/kg	0.021- 9.5 mg/kg

[1]Reference Samples were taken during the BERA investigation in areas considered background to the site.
Sample AQUAREF2 was eliminated from the reference sample group due to obvious site related contamination.

TABLE 3
Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water

Exposure Point	Chemical of Concern	Concentration Detected		Concentration Units	Frequency of Detection	Exposure Point Concentration (EPC)	EPC Units	Statistical Measure
		Min	Max					
Surface Water - Marsh	Arsenic	535	569	µg/l	2/2	569	µg/l	Maximum
Surface Water – Raritan River	Arsenic	5.9	20.3	µg/l	3/3	20	µg/l	Maximum

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	Chemical of Concern	Concentration Detected		Concentration Units	Frequency of Detection	Exposure Point Concentration (EPC)	EPC Units	Statistical Measure
		Min	Max					
Sediment - Marsh	Arsenic	342	4030	mg/kg	3/3	4030	mg/kg	Maximum
Sediment – Raritan River	Arsenic	37.8	2200	mg/kg	7/7	2200	mg/kg	Maximum

Scenario Timeframe: Current/Future

Medium: Shellfish

Exposure Medium: Shellfish

Exposure Point	Chemical of Concern	Concentration Detected		Concentration Units	Frequency of Detection	Exposure Point Concentration (EPC)	EPC Units	Statistical Measure
		Min	Max					
Shellfish – Raritan River	Arsenic	0.48	1	mg/kg	9/9	1	mg/kg	Maximum

Maximum: Maximum Detected Concentration

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

This table presents the chemicals of concern (COCs) and exposure point concentrations (EPCs) for each of the COCs detected in surface water, sediment, and shellfish (i.e., the concentration that will be used to estimate the exposure and risk from each COC). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the EPC and how it was derived.

TABLE 4
SELECTION OF EXPOSURE PATHWAYS

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/ Future	Surface Water	Surface Water	Marsh	Trespasser	Youth	Dermal/ Ingestion	On./Off -site	Quant	Potential exposure to sediments in the Marsh Area by adolescents.
				Residents	Adult	Dermal/ Ingestion	On/Off-Site	Quant	Potential exposure to surface water in the Marsh Area by future residents.
					Child	Ingestion	On/Off-site	Quant	Potential exposure to surface water in the Marsh Area by future residents.
			Raritan River	Trespasser	Youth	Dermal/ Ingestion	On-site	Quant	Potential exposure to sediments in the Raritan River by adolescents.
				Residents	Adult	Dermal/ Ingestion	On/Off-Site	Quant	Potential exposure to surface water in the Raritan River by future residents.
					Child	Ingestion	On/Off-site	Quant	Potential exposure to surface water in the Raritan River by future residents.
	Sediment	Sediment	Marsh	Trespasser	Youth	Dermal/Ingestion	On-site	Quant.	Potential exposure to sediments in the Marsh Area by adolescents.
				Residents	Adult	Dermal/ Ingestion	On/Off-Site	Quant	Potential exposure to sediments in the Marsh Area by future residents.
					Child	Ingestion	On/Off-site	Quant	Potential exposure to sediments in the Marsh Area by future residents.
			Raritan River	Trespasser	Youth	Dermal/ Ingestion	On-site	Quant	Potential exposure to sediments in the Raritan River by adolescents.
				Residents	Adult	Dermal/ Ingestion	On/Off-Site	Quant	Potential exposure to sediment in the Raritan River by future residents.
					Child	Ingestion	On/Off-site	Quant	Potential exposure to sediment in the Raritan River by future residents.
	Shellfish	Shellfish	Raritan River	Resident	Adult	Ingestion	On/Off-site	Quant.	Potential exposure to shellfish from the Raritan River by future residents.

Quant = Quantitative risk analysis performed.

Summary of Selection of Exposure Pathways

The table describes the exposure pathways associated with the surface water, sediments, and shellfish that were evaluated for the risk assessment, and the rationale for the inclusion of each pathway. Exposure media, exposure points, and characteristics of receptor populations are included.

TABLE 5

Non-Cancer Toxicity Data Summary

Pathway: Oral/Dermal

Chemical of Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Absorp. Efficiency (Dermal)	Adjusted RfD (Dermal)	Adj. Dermal RfD Units	Primary Target Organ	Combined Uncertainty /Modifying Factors	Sources of RfD: Target Organ	Dates of RfD:
Arsenic	Chronic	3.0E-04	mg/kg-day	100%	3.0E-04	mg/kg-day	Skin	3	IRIS	08/24/00

Key

NA: No information available
IRIS: Integrated Risk Information System, U.S. EPA
NCEA: National Center for Environmental Assessment
HEAST: Health Effects Assessment Summary Tables
R3 RBC: EPA Region 3 Risk-Based Concentration Table
CNS: Central Nervous System

Summary of Toxicity Assessment

This table provides non-carcinogenic risk information which is relevant to the contaminants of concern in surface water, sediment, and shellfish. When available, the chronic toxicity data have been used to develop oral reference doses (RfDs) and inhalation reference doses (RfDi).

TABLE 6

Cancer Toxicity Data Summary

Pathway: Oral/Dermal

Chemical of Concern	Oral Cancer Slope Factor	Units	Adjusted Cancer Slope Factor (for Dermal)	Slope Factor Units	Weight of Evidence/ Cancer Guideline Description	Source	Date
Arsenic	1.5E+00	$(mg/kg/day)^{-1}$	-----	$(mg/kg/day)^{-1}$	A	IRIS	08/24/00

Key:

IRIS: Integrated Risk Information System. U.S. EPA

NA: No information available

EPA Weight of Evidence:

A - Human carcinogen

B1 - Probable Human Carcinogen-Indicates that limited human data are available

B2 - Probable Human Carcinogen-Indicates sufficient evidence in animals associated with the site and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as a human carcinogen

E- Evidence of noncarcinogenicity

Summary of Toxicity Assessment

This table provides carcinogenic risk information which is relevant to the contaminants of concern in surface water, sediment, and shellfish. Toxicity data are provided for both the oral and inhalation routes of exposure.

TABLE 7

Risk Characterization Summary - Noncarcinogens

Scenario Timeframe: Future
Receptor Population: Resident

Receptor Age: Youth (12-17 years)

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Risk			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface water	Surface water	Marsh	Arsenic	Skin	5.7E-02	-----	1.0E-03	5.8E-02
Sediment	Sediment	Marsh	Arsenic	Skin	1.6E+00	-----	4.4E-01	2.0E+00
							Hazard Index Total	2.1E+00

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Youth (12-17 years)

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Risk			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface water	Surface water	Raritan River	Arsenic	Skin	2.0E-03	-----	3.7E-05	2.0E-03
Sediment	Sediment	Raritan River	Arsenic	Skin	8.8E-01	-----	2.4E-01	1.1E+00
							Hazard Index To	1.1E+00

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Risk			
					Ingestion	Inhalati on	Dermal	Exposure Routes Total
Surface water	Surface water	Marsh	Arsenic	Skin	2.3E-01	-----	1.1E-01	3.4E-01
Sediment	Sediment	Marsh	Arsenic	Skin	1.3E+00	-----	9.7E-01	2.2E+00
							Hazard Index Total	2.6E+00

Scenario Timeframe: Future
Receptor Population: Resident

Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Risk			
					Ingestion	Ingestion	Ingestion	Exposure Routes Total
Surface water	Surface water	Raritan River	Arsenic	Skin	8.0E-03	-----	3.7E-03	1.2E-02
Sediment	Sediment	Raritan River	Arsenic	Skin	6.9E-01	-----	5.3E-01	1.2E+00
Shellfish	Shellfish	Raritan River	Arsenic	Skin	3.0E-01	-----	-----	3.0E-01

							Hazard Index Total	1.5E+00

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Risk			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface water	Surface water	Marsh	Arsenic	Skin	1.1E+00	-----	1.7E-01	1.3E+00
Sediment	Sediment	Marsh	Arsenic	Skin	1.2E+01	-----	2.8E+00	15E+01
							Hazard Index Total	16E+00

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Risk			
					Ingestion	Inhalation	Ingestion	Exposure Routes Total
Surface water	Surface water	Raritan River	Arsenic	Skin	8.0E-03	-----	3.7E-03	1.2E-02
Sediment	Sediment	Raritan River	Arsenic	Skin	6.5E+00	-----	1.5E+00	8E+00
							Hazard Index Total	8.0E+00

Summary of Risk Characterization - Non-Carcinogens

The table presents hazard quotients (HQs) for each route of exposure and the hazard index (sum of hazard quotients) for all routes of exposure. The Risk Assessment Guidance for Superfund states that, generally, a hazard index (HI) greater than 1 indicates the potential for adverse non-cancer effects.

TABLE 8

Risk Characterization Summary - Carcinogens

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface water	Surface water	Marsh	Arsenic	3.5E-05	-----	1.6E-05	5.1E-05
Sediment	Sediment	Marsh	Arsenic	1.9E-04	-----	1.5E-04	3.4E-04
						Total Risk =	3.9E-04

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface water	Surface water	Raritan River	Arsenic	1.2E-06	-----	1.8E-06	1.8E-06
Sediment	Sediment	Raritan River	Arsenic	1.1E-04	-----	8.0E-05	1.9E-04
Shellfish	Shellfish	Raritan River	Arsenic	4.6E-05	-----	-----	4.6E-05
						Total Risk =	2.5E-04

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface water	Surface water	Marsh	Arsenic	4.2E-05	-----	6.7-E06	4.8E-05
Sediment	Sediment	Marsh	Arsenic	4.5E-04	-----	1.1E-04	5.6E-04
						Total Risk =	6.1E-04

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface water	Surface water	Raritan River	Arsenic	1.2E-06	-----	5.7E-07	1.8E-06
Sediment	Sediment	Raritan River	Arsenic	2.5E-04	-----	5.9E-05	3.1E-04
						Total Risk =	3.1E-04

Summary of Risk Characterization – Carcinogens

The table presents cancer risks for each route of exposure and for all routes of exposure combined. As stated in the National Contingency Plan, the acceptable risk range for site-related exposure is 10^{-6} to 10^{-4}.

Table 9
Preliminary Remediation Goals Identified in the Proposed Plan and the Final Remediation Goals
(See Page 18 of Decision Summary)

Site-Specific Receptor	Hazard /Risk	Arsenic (mg/kg)	Mercury (mg/kg)
Human Health Receptors			
Adolescent trespasser	10^{-6}	44	n/a
	10^{-4}	4,400	n/a
	HI = 1	2,000	n/a
Adult resident	10^{-6}	12	n/a
	10^{-4}	1,200	n/a
	HI = 1	1,850	n/a
Child Resident	10^{-6}	7.5	n/a
	10^{-4}	750	n/a
	HI = 1	285	n/a
Ecological Receptors			
Blackworm (biomass)	HI = 1	32	3.6
Earthworm (biomass)	HI = 1	1,050	15.5
Blackworm (survival)	HI = 1	17,800	68
Earthworm (survival)	HI = 1	17,800	68
Muskrat	HI = 1	183	24
Marsh Wren	HI = 1	1,470	8.86
Burrowing animals	HI = 1	160	n/a
Benthic organisms	HI = 1	n/a	2
Soil Background	n/a	14.7	0.14

Remediation Goals

Media	Arsenic (mg/kg)	Mercury (mg/kg)
River Sediments	100	2
Marsh Surface Sediments	32	2
Marsh Sediments (below 1')	160	n/a

*n/a – not applicable

APPENDIX III
ADMINISTRATIVE RECORD
INDEX

APPENDIX IV
STATE LETTER

APPENDIX V
RESPONSIVENESS SUMMARY